CBO PAPERS

THE FUTURE OF THEATER MISSILE DEFENSE

June 1994

CONGRESSIONAL BUDGET OFFICE

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NOTES

Unless otherwise indicated, all years referred to in this paper are fiscal years, and all costs are expressed in constant 1995 dollars of budget authority.

Numbers in text and tables may not add to totals because of rounding.

PREFACE

The United States has very limited means to protect its forces and the populations of its allies from attacks by theater ballistic missiles. This vulnerability was demonstrated when Iraq attacked Saudi Arabia and Israel with ballistic missiles during the Persian Gulf War. The Administration has presented a plan to improve the nation's ability to meet this threat, but critics have other ideas. Some believe that the Administration's plan goes too far. Others think that it does not go far enough.

This Congressional Budget Office (CBO) paper analyzes the costs and capabilities of the Administration's plan for theater missile defenses. The analysis covers all aspects of theater ballistic missile defense, including active defenses, passive defenses, counterforce operations, and the command and control systems that allow them to function effectively. It also examines the compliance issues that the plan may raise with the Anti-Ballistic Missile Treaty. Finally, it analyzes the costs and effects of several alternatives to the plan. This effort was requested by the Chairman of the Senate Budget Committee. In keeping with CBO's mandate to provide objective and nonpartisan analysis, the paper makes no recommendations.

This paper was prepared by David Mosher and Raymond Hall. Mosher of CBO's National Security Division organized and prepared this analysis under the supervision of Neil M. Singer and R. William Thomas. Hall of CBO's Budget Analysis Division performed the cost analysis under the supervision of Michael Miller. Geoff Cohen analyzed the capabilities of various systems. Karen Ann Watkins provided the research on proliferation. Ivan Eland thoroughly reviewed the manuscript and provided useful comments. The authors would like to thank Jon Wolfsthal, David Wright, Dr. Charles Johnson, and the people at POET, and the numerous people with the services and the Department of Defense who provided invaluable help and comments. Of course, all responsibility for the paper lies with the authors and CBO.

Paul L. Houts edited the text, and Leah Mazade provided editorial assistance. Cindy Cleveland prepared the manuscript for publication.

Robert D. Reischauer
Director

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SUMMARY

The United States has very limited means to protect its forces and the populations of its allies against attacks by theater ballistic missiles. Iraq's attacks on Saudi Arabia and Israel during the Persian Gulf War alerted U.S. leaders to the threat these missiles pose. Batteries of U.S. Patriot missiles were deployed to defend important military assets and population centers but were stretched to the limit defending large urban areas--a mission for which they were not designed. Space-based early-warning sensors detected missile launches but had difficulty communicating warning messages in a timely fashion. In addition, U.S. aircraft had great difficulty locating and destroying Iraq's mobile missile launchers. Despite the large number of aircraft dedicated to that mission, analysis done by the Department of Defense (DoD) after the war could not confirm that air power destroyed even one launcher.

Since the war, a consensus has emerged that U.S. forces should be better able to protect themselves against such threats. To that end, the Congress has increased funding for theater ballistic missile defense (TMD) efforts within the Ballistic Missile Defense Organization (BMDO) from less than $200 million annually before the war to some $2 billion in 1994. The war also pointed out that the United States should work harder to prevent the proliferation of these weapons.

But how much protection is enough? Some Members of Congress want to reduce the scope of the Administration's program for reasons of budget or treaty compliance; others think that the Department of Defense should invest more to address the threat posed by those weapons.

This paper examines the Administration's plan for theater ballistic missile defenses. As coalition forces found during the Persian Gulf War, an effective defense against theater ballistic missiles requires more than just active defenses like the Patriots that are intended to destroy missiles once they have been launched. U.S. forces can also take passive defense measures, such as dispersing themselves or using protective clothing and shelters to minimize the effects of any missiles that penetrate active defenses. To reduce the burden placed on active defenses, they can also conduct counterforce, or attack, operations to disrupt or destroy an adversary's ability to launch ballistic missiles or use unconventional weapons. Finally, those efforts need to have sensors as well as command, control, and communications systems to allow them to function effectively. Perhaps most important, the United States

should strive to limit the proliferation of theater ballistic missiles and the weapons of mass destruction that they might carry.

DoD includes all four of these so-called pillars in its conceptual framework for TMD. Because active defenses receive the lion's share of the total theater missile defense budget, much of this paper focuses on that effort. However, the paper also describes DoD's efforts to improve its ability to conduct attack operations and its ability to detect and track theater ballistic missiles from space. Funding for these activities comes mostly from the Ballistic Missile Defense Organization, but the services and other agencies also contribute to the overall theater missile defense effort from their own budgets.

Although not addressed in this paper, the Administration is working to halt proliferation of weapons of mass destruction and the ballistic and cruise missiles that can carry them.

THE ADMINISTRATION'S PLAN FOR ACTIVE DEFENSES

The Ballistic Missile Defense Organization is currently developing three types of active defenses to counter theater ballistic missiles (see Summary Table 1). Point defenses like the Patriot can protect small areas such as airfields, ports, or command and control facilities. Point defenses are also called lower-tier defenses because they intercept targets in the lower regions of the atmosphere. Upper-tier (or area) defenses would be able to protect areas a few hundred kilometers across because they would intercept missiles at greater ranges, high in the atmosphere or above it altogether. Together the two tiers provide a layered defense that increases the effectiveness in areas that are protected by both. The Ballistic Missile Defense Organization is also developing "boost-phase defenses" that will intercept missiles during the initial, or boost, phase of their flight when the missile motor is still burning.

The Core Systems

The Administration plans to develop active theater missile defense systems using a phased approach. It plans to develop a core of three systems over the next five years and develop other systems during the next decade. The core package consists of two point defenses, Patriot Advanced Capability, Level 3 (PAC-3), and the Navy lower-tier defense, and one area defense, the Theater High-Altitude Area Defense (THAAD). The core package also includes a command and control system.

SUMMARY TABLE 1. ACTIVE THEATER BALLISTIC MISSILE DEFENSE SYSTEMS AND RELATED SPACE-BASED SENSORS CURRENTLY BEING DEVELOPED BY DOD

System	Service	Funding Agency
	Lower-Tier (Point) Defenses	
PAC-2 Upgrades	Army	BMDO/Army
PAC-3 (with ERINT)	Army	BMDO
Corps SAM[a]	Army	BMDO
Navy Lower-Tier Defense	Navy	BMDO
Hawk Upgrades	Marines	BMDO
	Upper-Tier (Area) Defenses	
THAAD (Includes TMD-GBR)	Army	BMDO
Navy Upper-Tier Defense[a]	Navy	BMDO
Arrow	Israel[b]	BMDO/Israel
	Boost-Phase Defenses	
Boost-Phase Interceptor[a,c]	Air Force	BMDO/Air Force
Airborne Laser	Air Force	Air Force
	Space-Based Sensors	
Brilliant Eyes	Air Force	BMDO
ALARM	Air Force	Air Force

SOURCE: Congressional Budget Office based on Department of Defense data.

NOTES: DoD = Department of Defense; PAC = Patriot Advanced Capability; BMDO = Ballistic Missile Defense Organization; ERINT = Extended-Range Interceptor; SAM = Surface-to-Air Missile; THAAD = Theater High Altitude Area Defense; TMD-GBR = Theater Missile Defense Ground-Based Radar; ALARM = Alert, Locate, and Report Missiles.

a. BMDO has designated Corps SAM, the Navy upper-tier defense, and the boost-phase interceptor as advanced-capability TMD systems. In 1998, it plans to select one for further development and production based on guidance from the Joint Chiefs of Staff. If budgets beyond 1999 permit, the other two may be developed later.
b. Israel is developing the Arrow system with substantial financial and technical contributions from the United States.
c. As currently envisioned by the Air Force, the boost-phase interceptor will require a large airborne radar that has yet to be developed.

The Army's PAC-3 is a land-based air defense system designed to protect important military targets at the rear of a theater of operations such as airfields, ports, and command and logistics centers. PAC-3 will be a significantly improved version of the Patriot system that the United States deployed during the Persian Gulf War. According to the Ballistic Missile Defense Organization, it will cost $3 billion to complete the PAC-3 development program and to buy 1,500 missiles and modify 180 launchers and 74 radars. (All costs in this paper are expressed in fiscal year 1995 dollars.) The first PAC-3 interceptors will be deployed toward the end of 1998 (see Summary Table 2).

Like the Patriot, the Navy's lower-tier system can protect point targets, but only those that are situated near a coast. This ability makes it a natural choice to protect ports, key areas of coastal cities, and Marine amphibious forces. The Navy intends to modify the warhead and fuze of the Standard Block IV missile and the software of the Aegis radar that are deployed on modern cruisers and destroyers. The Ballistic Missile Defense Organization estimates that it will cost $3.8 billion to complete the Navy lower-tier system. It plans to deploy the first Navy lower-tier system in 1999, though it intends to have a prototype version available as soon as the end of 1997 that could be deployed during a crisis.

The Army's Theater High Altitude Area Defense will provide the upper-tier defense for the core package. THAAD will protect an area a few hundred kilometers across against a missile with a range of 600 kilometers like the Al Husseins that Iraq used during the Persian Gulf War. It will also improve the effectiveness of the lower-tier defenses by reducing the number of incoming missiles they face. THAAD will typically be deployed toward the rear of the theater to provide maximum protection to key military and civilian targets and to reduce its own vulnerability.

Unlike the Patriot and the Navy lower-tier defense, THAAD is an entirely new system. The Ballistic Missile Defense Organization estimates that it will cost $9.1 billion to complete the THAAD program and purchase 1,313 missiles and 14 batteries, each consisting of one command center, one radar, and four to six launchers. The Army will deploy THAAD beginning in 2001, according to current plans. However, the Ballistic Missile Defense Organization plans to have deployable prototypes of THAAD and its radar available for contingencies by the end of 1996. Those deployment dates may depend on an agreement between the United States, Russia, and the other parties to the Anti-Ballistic Missile Treaty that THAAD complies with the treaty.

SUMMARY TABLE 2. QUANTITIES AND TOTAL COSTS OF ACTIVE THEATER BALLISTIC MISSILE DEFENSES AND RELATED SENSORS BEING DEVELOPED BY DOD

System	Quantities[a] Missiles	Launchers	Radars	Initial Deployment Date	Cost to Complete[b] (Billions of 1995 dollars)
		Core Systems			
PAC-3 (with ERINT)	1,500	180[c]	74[c]	1998	3.0
Navy Lower-Tier Defense	1,820	50[d]	50[d]	1999[e]	3.8
THAAD (with TMD-GBR)	1,313	80	14	2001[e]	9.1
		Advanced-Capability TMD Systems			
Concept Development of Corps SAM, Navy Upper-Tier, and Boost-Phase Interceptor	n.a.	n.a.	n.a.	n.a.	2.1
Development and Production of One System[f]	N.A.	N.A.	N.A.	N.A.	11.0
		Related Space-Based Sensors			
Brilliant Eyes	28[g]	n.a.	n.a.	2004[h]	3.3
ALARM	12[g]	n.a.	n.a.	2004[h]	12.1

SOURCE: Congressional Budget Office based on Department of Defense data.

NOTES: DOD = Department of Defense; PAC = Patriot Advanced Capability; ERINT = Extended-Range Interceptor; THAAD = Theater High Altitude Area Defense; TMD-GBR = Theater Missile Defense Ground-Based Radar; TMD = theater missile defense; SAM = Surface-to-Air Missile; ALARM = Alert, Locate, and Report Missiles; n.a. = not applicable; N.A. = not available.

a. Quantities refer to production items only. Those required for development and testing are not listed here.

b. Costs include research, development, testing, and production; they exclude funds appropriated before 1995 and the costs to operate and support the systems after they have been deployed.

c. To accommodate the new missiles and mission, the Army will modify existing Patriot launchers and radars rather than purchase new ones.

d. The Standard Block IVA missiles will be deployed in existing vertical launchers on about 50 Aegis ships and destroyers by 2000. Radars on these ships will be modified.

e. The Ballistic Missile Defense Organization (BMDO) plans to have a deployable prototype of the THAAD and Navy lower-tier systems that will be available by 1996 and 1997, respectively, for use during a crisis. These will be called User Operational Evaluation Systems (UOES).

f. In 1998, BMDO will select one of the three advanced-capability TMD systems for development and production. The other two may be developed later, if budget constraints beyond 1999 permit. The cost of Corps SAM development and production is listed here; the costs of the others are not available.

g. The figure indicates number of satellites, not missiles.

h. This is the delivery date; deployment dates are unavailable.

Advanced-Capability Theater Missile Defense Systems. The Ballistic Missile Defense Organization is developing three other theater missile defenses as candidate advanced-capability theater missile defense systems: a sea-based upper-tier defense, a mobile Army point defense called the Corps Surface-to-Air Missile (Corps SAM), and an Air Force boost-phase interceptor. All three will be funded at a modest level through 1999. Because of budget constraints, however, the Ballistic Missile Defense Organization expects to deploy only one of those systems. For the two systems that are not chosen, it plans further development beyond 1999 as budget conditions permit.

The Navy's upper-tier defense would have a role similar to THAAD--namely, to provide an upper layer of protection. The biggest advantage of this sea-based system is that it would not need to rely on the availability of secure airfields to be transported to the theater. Thus, it could be employed more quickly than THAAD, provided that ships were nearby when the crisis erupted and THAAD batteries had been deployed before the crisis began.

The Army, with funding from the Ballistic Missile Defense Organization, is developing an air defense system (Corps SAM) to deploy with its frontline, or "maneuver," forces. Those forces are often left unprotected by the Patriot system, which is deployed to the rear of the theater to protect important fixed targets. Corps SAM would replace Army and Marine Corps Hawk air-defense batteries. Although it will be designed primarily as a defense against aircraft and cruise missiles, the system will be able to provide defenses against theater ballistic missiles with ranges of less than 600 kilometers (km). According to estimates of the Ballistic Missile Defense Organization, Corps SAM will cost $11.0 billion to develop and purchase, in addition to the $500 million spent on developing the concept.

The third candidate is the Air Force's boost-phase interceptor--a missile carried by manned air-superiority fighters. In one approach, fighters, loaded with one or two missiles each, would fly racetrack patterns near suspected missile launch areas. The fighters would rely on a large airborne radar similar to the Airborne Warning and Control System (AWACS) or the Joint Surveillance and Target Attack Radar System (JSTARS) that would detect and track the missile and tell the fighters where to point their weapons. This radar aircraft--which the Air Force is calling the multipurpose sensor and cueing platform--does not exist today and would require a new acquisition program.

Through 1999, the Ballistic Missile Defense Organization and the Air Force will request some $500 million for the boost-phase interceptor. However, no estimate of total cost is available; it is an entirely new program

that is still in the early phase of its development. Nor are estimates available for the airborne multipurpose sensor and cueing platform.

PASSIVE DEFENSES AND ATTACK OPERATIONS

Passive defenses and attack operations are not commonly considered part of theater missile defense. Yet both of these pillars play an important role in protecting U.S. forces and the populations of our allies against ballistic missile attacks.

Passive Defenses

There are two types of passive defenses: operational measures such as dispersing forces to minimize the effect that any one missile warhead can have; and technical measures such as developing and purchasing detection devices, protective clothing, and decontamination facilities. Although DoD is improving passive defenses, it has no specific programs related to protecting forces from theater ballistic missiles. Rather, the focus of its passive defense efforts is on protective measures against the unconventional weapons that can be carried by many platforms.

Attack Operations: Disrupting Missile Launch Operations

Attack operations--disrupting an adversary's ability to launch ballistic missiles during a war--can be an important method for limiting the damage it can inflict on U.S. forces and the civilian populations of allies. Fewer missiles launched means that fewer can reach their targets. Attack operations seek to disrupt launches by attacking manufacturing facilities, garrisons, hiding places, launchers, and the command and control system through which the launcher receives its orders to launch.

Finding mobile missile launchers is one of the most challenging aspects of theater missile defense. The difficulty that coalition forces had in finding Scud launchers during the Persian Gulf War and Iraq's effective use of decoys and hiding illustrates what a daunting task it can be. Hunting missiles would be considerably more difficult in North Korea's mountainous regions or Bosnia's forested areas.

Nonetheless, the attack operations against Iraqi Scuds were not fruitless. At the very least, the operation forced the Iraqis to launch their Scuds from

sites that were not well surveyed, which decreased the accuracy of their missile strikes. Data also suggest that attack operations may have reduced the number of missiles that Iraq was able to launch each day.

Mindful of its experience in the Persian Gulf War, DoD is working to improve its ability to detect, track, and destroy mobile missile launchers. The difficulty of the task will require the combined effort of all the services and special operations forces. The services currently have only small efforts under way to study how better to use existing assets. The Air Force has budgeted roughly $30 million annually for this effort. The Pentagon's Advanced Research Projects Agency has a program called Warbreaker to address U.S. shortcomings against "time-critical" mobile targets, of which ballistic missile launchers are perhaps the most prominent. DoD has requested $100 million for Warbreaker in 1995 and has budgeted about $140 million per year thereafter.

TMD-RELATED SPACE-BASED SENSORS

In addition to the active defenses and attack operations capabilities described above, DoD is developing two space-based sensors that are important elements of the overall theater missile defense architecture. The Air Force is developing an improved early-warning satellite. At the same time, the Ballistic Missile Defense Organization is developing a sophisticated satellite-based sensor called Brilliant Eyes that is designed to track ballistic missiles when they are outside of the earth's atmosphere.

ALARM Early-Warning Satellite

The Air Force is developing a system of early-warning satellites to replace its existing Defense Support Program satellites, which were designed to detect launches of Soviet strategic missiles. In addition, the service plans to give the new system a better capability to detect and track theater ballistic missiles. Its name--Alert, Locate, and Report Missiles (ALARM)--reflects this new mission. Tracking data from ALARM will help terminal defenses like Patriot and THAAD focus their radar on a smaller portion of sky, thereby extending the range of their radar and increasing somewhat the size of the area that they can defend. ALARM will also help other sensor systems locate and track the empty mobile launchers so that they can be destroyed. DoD has budgeted more than $12 billion to develop ALARM and produce 12 satellites through 2018 (see Summary Table 2).

Brilliant Eyes

The Ballistic Missile Defense Organization is developing a system of space-based sensors called Brilliant Eyes to track theater ballistic missiles more accurately than is possible with early-warning satellites. (BMDO is also using the name Space and Missile Tracking System for Brilliant Eyes.) Those sensors will help distinguish targets from decoys. Originally designed as an important component for a national missile defense--that is, a defense of the United States against intercontinental ballistic missiles--Brilliant Eyes is now being touted as well for its ability to enhance theater as well as national missile defenses.

The tracking information (also called cueing data) from these satellites is supposed to be accurate enough that missile intercepts can occur entirely beyond the range of the theater missile defense radar. Such a capability would greatly expand the area that an upper-tier defense like THAAD could defend against longer-range theater ballistic missiles. However, currently planned active defenses will be unable to take full advantage of the capabilities of Brilliant Eyes, which itself will also lack the required communications equipment, according to current plans. Instead, data from the sensors will cue their radar and may allow interceptors to be launched before the radar can see them. The Ballistic Missile Defense Organization considers the system important enough to devote $100 million to $200 million to it annually. The first of the planned 28 production satellites will be delivered in 2004. The Ballistic Missile Defense Organization estimates that the Brilliant Eyes program will cost $3.3 billion to complete.

The Costs of the Administration's Plan

The Administration will spend some $2.7 billion on theater missile defense in 1995, including almost $300 million for TMD-related space-based sensors. The lion's share of this (83 percent) will be spent by the Ballistic Missile Defense Organization for active theater missile defense and Brilliant Eyes. The remaining $500 million will be spent primarily by the Air Force, the Army, and the Advanced Research Projects Agency. Together, these efforts make up the Administration's budget for developing theater missile defenses (see Summary Table 3).

SUMMARY TABLE 3. CBO'S ESTIMATE OF THE ADMINISTRATION'S BUDGET REQUEST FOR THEATER MISSILE DEFENSE AND SPACE-BASED SENSORS
(By fiscal year, in billions of 1995 dollars)

Category	1995	1996	1997	1998	1999	Total 1995 to 1999	Total 1999 to 2010	Total 1995 to 2010
				BMDO's Theater Missile Defense Activities				
Core Systems								
PAC-3	0.6	0.7	0.5	0.5	0.4	2.5	0.4	3.0
THAAD/GBR	0.7	0.6	0.6	0.7	1.0	3.5	5.6	9.1
Navy lower-tier	0.2	0.3	0.3	0.3	0.2	1.3	2.6	3.9
Battle management	a	a	0.1	0.1	a	0.3	0.4	0.7
Subtotal	1.5	1.6	1.4	1.5	1.7	7.7	9.0	16.7
Advanced-Capability TMD Systems								
Corps SAM	a	a	a	a	a	0.1	0.3	0.5
Navy upper-tier	a	a	a	a	a	0.1	0.3	0.5
Boost-phase interceptor	0.1	0.1	0.1	0.1	0.1	0.3	0.7	1.1
Dem/Val Program	0.0	0.0	0.0	0.2	0.2	0.4	10.3	10.7[b]
Subtotal	0.1	0.1	0.1	0.3	0.4	1.0	11.7	12.8
TMD Research and Support	0.4	0.4	0.4	0.4	0.4	2.0	3.4	5.4
International Programs	0.1	a	a	a	a	0.2	0.4	0.6
Total	2.1	2.2	2.0	2.3	2.5	10.9	24.5	35.5
				Other Theater Missile Defense Activities				
Air Force TMD								
Airborne laser	a	a	a	a	a	0.2	0.2	0.4
Attack operations	a	a	a	a	a	0.1	0.3	0.4
Boost-phase interceptor	0.1	0.1	0.1	a	a	0.2	0.2	0.4
Army Patriot Upgrades	0.1	a	a	a	a	0.2	0.0	0.2
Warbreaker Program	0.1	0.1	0.1	0.1	0.1	0.7	1.2	1.8
Total	0.3	0.3	0.3	0.2	0.2	1.3	1.8	3.1
				TMD-Related Space-Based Sensors				
ALARM	0.2	0.2	0.1	0.3	0.5	1.2	6.9	8.1[b]
Brilliant Eyes	0.1	0.1	0.1	0.2	0.2	0.8	2.5	3.3
				Total Theater Missile Defense and Space-Based Sensors				
All Programs	2.7	2.8	2.6	2.9	3.4	14.3	35.7	50.0

SOURCE: Congressional Budget Office based on information from the Department of Defense.

NOTES: Costs exclude those to operate a system after it has been deployed. BMDO = Ballistic Missile Defense Organization; PAC = Patriot Advanced Capability; THAAD = Theater High Altitude Area Defense; GBR = Ground-Based Radar; TMD = Theater Missile Defense; SAM = Surface-to-Air Missile; Dem/Val = Demonstration and Validation; ALARM = Alert, Locate, and Report Missiles.

a. Less than $50 million.

b. Total costs for advanced-capability TMD and ALARM are higher than these figures because the programs continue beyond 2010.

Through 2010, DoD plans to spend $50 billion (in 1995 dollars) on all theater ballistic missile defense activities, including $36.3 billion for active defenses (of which BMDO's theater missile defense efforts will require $35.5 billion). It has budgeted $11.4 billion for space-based sensors related to theater missile defenses and $2.2 billion for attack operations. However, these budgets will fund research and procurement only. They exclude the money that will be necessary to operate and support those systems once they have been deployed.

THEATER MISSILE DEFENSE AND THE ANTI-BALLISTIC MISSILE TREATY

The Administration's plan for theater missile defense raises several important issues with the Anti-Ballistic Missile (ABM) Treaty. Primary among them is determining the dividing line between theater and strategic missile defenses. The treaty sharply limits the ability of the United States and Russia to defend their territory against ballistic missiles with intercontinental ranges, so-called strategic missiles. The treaty does not limit theater ballistic missile defenses, but it has provisions that prohibit giving them capabilities to counter strategic ballistic missiles and "testing them in an ABM mode." However, the treaty does not define what constitutes a strategic missile.

This ambiguity was never resolved during the Cold War because neither the United States nor the Soviet Union developed sophisticated theater missile defenses. Rather, the problem facing negotiators of the first Strategic Arms Limitations Talks (SALT I) Treaty was distinguishing between defenses against aircraft and strategic ballistic missile defenses--an easier distinction to make. Today, however, the threat of nuclear war between the United States and Russia has receded dramatically, and the threat from theater ballistic missiles that have spread to other regions of the world has become more prominent. In this context, resolving the treaty's ambiguity about the demarcation between theater and strategic defenses has become critical.

How permissive this new dividing line should be is currently the subject of a vigorous debate. In November of 1993, according to published reports, the Administration proposed to Russia that a strategic missile defense be defined as one that has been tested against a target with a maximum speed greater than five kilometers per second. It also proposed that the ABM treaty be clarified so that only those systems demonstrated to have ABM capability would violate the treaty. The current version of the treaty limits any system with the capability to intercept strategic missiles, whether that system has been tested or not. The proposal would allow the United States to deploy

THAAD, the Navy upper-tier defense, and boost-phase interceptors or any other system that has not been tested against a target with speeds above the threshold. The Administration's initial position may well have been changed somewhat during the course of negotiations, but no changes have been reported. Consequently, debate has focused on the original proposal.

Critics have raised several objections to the Administration's proposal. First, the threshold is too high, they argue. Any system, they contend, that can offer defense against a missile traveling at 5 kilometers per second can defend an area almost as large against a strategic missile. Second, critics maintain that the proposal would allow theater missile defenses more capable than THAAD to be developed--ones that had unambiguous ABM capabilities. As a result, an ABM system masquerading as a theater missile defense could be deployed legally under the Administration's proposal as long as it was not tested against a target traveling faster than the new threshold. In their view, the proposal will weaken the ABM treaty and make both Russia and the United States reluctant to reduce further the size of their strategic nuclear arsenals. In addition, they contend that such changes could seriously affect future nuclear planning by the smaller nuclear powers: China, the United Kingdom, and France.

Supporters of the Administration's proposal argue that the 5-kilometers-per-second threshold is necessary to permit the United States to develop defenses that can provide protection against long-range theater ballistic missiles. That speed corresponds to a missile with a range of roughly 3,000 kilometers. They also argue that long-range theater ballistic missiles are on the horizon--Saudi Arabia and Israel have deployed such missiles, India has tested a 2,500 kilometer missile, and North Korea has tested a missile that may ultimately have a range of 1,000 kilometers. Furthermore, North Korea is in the early stages of developing as many as two missiles with ranges greater than 1,000 kilometers.

Although supporters acknowledge that a system like THAAD will have some capability against strategic missiles, they discount its significance. They maintain that, unlike missiles in the developing world, both Russian and U.S. strategic missiles have so-called penetration aids and other countermeasures that will easily defeat such systems. More important, according to some supporters, the Administration's proposed changes are essential to keep the ABM viable in a world with longer-range theater ballistic missiles.

Critics counter that the threat from long-range missiles is overstated. In its report on the National Defense Authorization Act for Fiscal Year 1995, the House Armed Services Committee cites data from the Department of

Defense that 97 percent of the threat from theater ballistic missiles is from those with ranges of 1,000 kilometers or less. Other than the 2,700 kilometer CSS-2 and the 1,500 kilometer Jericho II (which are deployed by U.S. allies Saudi Arabia and Israel, respectively), all missiles deployed in the developing world today have ranges of less than 700 kilometers and maximum speeds of less than 2.3 kilometers per second. Furthermore, according to critics, developing penetration aids should be easy for a developing country that is capable of building a 3,500 kilometer missile. In their view, an advanced theater missile defense that is capable of dealing with penetration aids will have a similar capability against strategic missiles. Thus, they contend, the limit on target speeds proposed by the Administration cannot, by itself, provide a sufficient buffer between theater and strategic missile defenses. Other limits must be included.

Finally, the Administration's proposal has come under fire by those who believe that the United States should be building missile defenses to protect the United States, such as those planned by the Reagan and Bush Administrations. They are not happy that the present Administration has withdrawn proposals made by those earlier Administrations that would have allowed the United States to deploy a more robust ABM system than the treaty presently allows.

The Russian delegation has not accepted the Administration's proposal, but neither has it rejected it outright, according to published reports. Since December, Russia has made several counterproposals seeking to limit further the capability of theater missile defenses. Among them are reportedly proposals to restrict the locations where these systems could be deployed and to limit the speed of TMD interceptors to 3 kilometers per second. Such a limitation would allow THAAD but probably forbid boost-phase interceptors and the Navy's area defense as currently envisioned. At publication time, those issues had not been resolved and negotiations were continuing. Nor were there any indications of how much the Administration had modified its original proposal to address Russia's concerns.

Space-based sensors also raise issues with the ABM treaty. First, at what point might a system like Brilliant Eyes become a substitute for an ABM radar, a key element of an ABM system that is strictly limited by the treaty to guard against either side's breaking out of the limits of the treaty and quickly deploying defenses? Second, would Brilliant Eyes increase the capability of theater missile defenses enough that they would have a significant capability against strategic missiles? The Administration will have to resolve these questions with Russia and to the satisfaction of the Congress before any controversial systems can be tested and deployed.

ALTERNATIVES TO THE ADMINISTRATION'S PLAN FOR THEATER MISSILE DEFENSE

Several criticisms have been leveled at the Administration's plan for theater missile defense. Some believe that it is too costly. Others worry about the issues that some systems would raise with the ABM treaty. Still others contend that the Administration does not plan to spend enough on those programs.

To illustrate the effects of different approaches to theater missile defenses that would address some of these concerns, the Congressional Budget Office (CBO) has analyzed four alternatives to the Administration's plan. The first option would deploy point defenses only and not area defenses such as THAAD. Option II would fund the Administration's core systems--PAC-3, THAAD, and Navy lower-tier defense--but it would not develop other systems like Corps SAM, boost-phase interceptors, or Navy upper-tier defense. Option III is exactly like Option II except that it would also deploy Brilliant Eyes. The final option CBO analyzed would develop noncore systems more quickly than the Administration's plan.

None of these options would affect funding for nontheater missile defense efforts within the Ballistic Missile Defense Organization, with the exception of Brilliant Eyes. Nor would any of the options affect funding for other means of reducing the threat of theater ballistic missiles--attack operations, passive defenses, efforts to control proliferation, or measures to reduce the likelihood of conflict. However, the savings that the options achieve by reducing active defenses could be used to augment funding for those other efforts.

Option I: Deploy Point Defenses Only

Option I is a low-cost approach to theater missile defense that would comply with the ABM treaty as currently interpreted. It would deploy the PAC-3 system and the Navy lower-tier defense but would not develop area defenses such as THAAD or boost-phase defenses (see Summary Table 4). This option would also develop the first version of ALARM, although it would not fund the upgrades planned for the second and third blocks of satellites. Nor would it develop the Brilliant Eyes space-based sensors.

SUMMARY TABLE 4. ALTERNATIVES TO THE ADMINISTRATION'S PLAN FOR THEATER MISSILE DEFENSE

	Core TMD Systems			Advanced-Capability TMD[b]	TMD-Related Space-Based Sensors		Savings[a] (Billions of 1995 dollars)	
	PAC-3	Navy Lower-Tier	THAAD		Brilliant Eyes	ALARM Upgrades[c]	1995	1995 to 2010
Administration's Plan	X	X	X	X	X	X	N.A.	N.A.
I. Deploy Point Defenses Only	X	X					1.0	27.2
II. Deploy Core Systems	X	X	X				0.3	18.6
III. Deploy Core Systems and Brilliant Eyes	X	X	X		X		0.1	15.3
IV. Increase Funding for Advanced-Capability TMD	X	X	X	X[d]	X	X	-0.2	-3.2

SOURCE: Congressional Budget Office.

NOTES: All options leave unchanged the Administration's plan for attack operations and national missile defenses (with the exception of Brilliant Eyes). TMD = Theater Missile Defense; PAC = Patriot Advanced Capability; THAAD = Theater High Altitude Area Defense; ALARM = Alert, Locate, and Report Missiles; N.A. = not available.

a. These estimates exclude any savings achieved by not having to operate systems that have been canceled.

b. The Ballistic Missile Defense Organization plans to select one of these systems in 1998 for full development and production. The other two would be developed beyond 1999 if budget constraints permit.

c. All options develop the first generation of ALARM early-warning satellites. However, some options do not fund the upgrades planned by the Air Force.

d. This option adds $200 million per year to the Administration's budget for the three advanced-capability theater missile defense systems (Corps Surface-to-Air Missile, Navy Upper-Tier, and Boost-Phase Interceptor). It would accelerate deployment of at least one of those systems but does not specify which ones would be affected.

Option I would save substantial sums. In 1995, for example, it would save $1.0 billion from the Administration's request of $2.7 billion. From 1995 through 1999, this option would save $5.6 billion. Most of those savings through 1999 would come from canceling THAAD ($3.4 billion); the remaining savings would come from eliminating the advanced-capability TMD systems ($1.0 billion) and Brilliant Eyes ($0.8 billion), and making a 20 percent reduction in the operational support funding for theater missile defense efforts within the BMDO budget to reflect the smaller scope of the theater missile defense project. Through 2010, this option would save $27.2 billion relative to CBO's estimate of the Administration's plan.

The option would have significant effects on capability compared with the Administration's plan. Point defenses may be effective enough to protect assets toward the rear of the theater from most ballistic missiles available today. Those defenses would be less effective, however, against longer-range missiles. Without an upper layer, PAC-3 and the Navy lower-tier defense will have more difficulty defending their relatively small areas against a wide range of threats, and more of them would have to be deployed to defend area targets like cities. Moreover, point defenses by themselves may not provide adequate protection against missiles armed with nuclear, chemical, or biological warheads. These weapons may disperse their agents too high in the atmosphere for most intercepts to occur. If area defenses are required to protect allied populations, this option would require allied nations to develop such defenses themselves.

By developing only the first generation of ALARM satellites, the option would provide U.S. commanders with the ability to detect and track shorter-range theater ballistic missiles such as Scud-Bs in two regions of the world, but not the ability to detect such missiles worldwide. Nor would it allow data from the satellite to be transmitted directly to theater commanders and other sensor platforms in the theater. However, U.S. forces may not be deployed in more than two regional conflicts simultaneously, so continuous global coverage might not be needed. Furthermore, data from ALARM will still be transmitted to the theater as fast, if not faster, than data from the Defense Support Program was during the Persian Gulf War. It will provide less warning of an impending attack than future generations of ALARM. But given the events in the war, a few minutes may be sufficient, particularly against longer-range missiles.

Option II: Deploy The Core Theater Missile Defense Systems

Option II would deploy a robust multitiered defense featuring the three core theater missile defense systems that the Ballistic Missile Defense Organization plans to develop over the next five years: THAAD, PAC-3, and the Navy lower-tier defense. In most other respects, the two options are the same; they both cancel advanced-capability theater missile defense systems and Brilliant Eyes.

Option II would save about $300 million in 1995 and $2.0 billion through 1999 relative to the Administration's plan for all theater missile defense activities. Through 2010, this option would save nearly $19 billion, much of it from canceling the three advanced-capability theater missile defense systems ($12.8 billion) and Brilliant Eyes ($3.3 billion). Smaller savings of about $500 million would accrue from a 10 percent reduction in the operational support funding for theater missile defense efforts--about half the level from Option I.

Those savings, however, would not arise without reducing the capability of the defenses relative to the Administration's plan. Forgoing boost-phase interceptors would not only reduce the number of layers that could intercept a missile, but it would reduce the ability of U.S. forces to intercept those missiles tipped with unconventional warheads over an adversary's territory. Canceling the sea-based upper-tier defense would eliminate the ability to provide area defense in the future without having to rely on airfields for deployment. It would also reduce the ability of U.S. forces to defend wide areas of Japan and Europe in the future if they were attacked by missiles from North Korea or Iraq, respectively. Canceling Corps SAM would significantly reduce the future ability of U.S. maneuver forces deployed near the front to protect themselves against short- and medium-range ballistic missiles. Finally, canceling the Brilliant Eyes program would foreclose the option of providing midcourse tracking and cueing data to expand the areas that a THAAD battery could defend. It would also eliminate an important component of any future national missile defense.

Nevertheless, Option II would provide the same capability to protect both point and area targets that the Administration plans to deploy over the next decade. Most significant, it would deploy THAAD to provide an upper tier. It would just not continue to develop more advanced defenses or sensors.

Good reasons may exist for canceling those systems. For example, in the face of U.S. air supremacy, regional adversaries may never develop the

ability to locate U.S. maneuver forces and attack them effectively with ballistic missiles. Thus, Corps SAM may not be needed for ballistic missile defense, although the need to protect against cruise missiles may remain. Boost-phase interceptors and the airborne sensor platforms that they are likely to require may be too expensive given that they will have to rely on terminal defenses to intercept the missiles that were launched out of their range. Sea-based upper-tier defense would duplicate THAAD for defending U.S. land-based forces in many cases. In addition, one of its most promising features--defending allies such as Japan and Europe from attacks by theater ballistic missiles over water--is perhaps most appropriately paid for by those other countries.

This option should also mitigate to some degree the concerns of ABM supporters who worry that the Administration's proposed clarification would undermine the treaty. The only area defense it would deploy is THAAD, whose interceptor has a maximum speed within the range reportedly acceptable to Russia. By not developing Brilliant Eyes further, Option II also avoids any issues that these sensors may raise with the treaty.

Option III: Deploy the Core Theater Missile Defense Systems and Brilliant Eyes

This option is much like Option II except that it would also develop Brilliant Eyes. Although this approach would be more expensive, it may provide a better mix of sensors for theater missile defense. Option III would save more than $100 million in 1995, relative to the Administration's plan, primarily by halting the development of the advanced-capability theater missile defense systems. Through 1999 it would save about $1.2 billion, and through 2010 it would reduce the theater missile defense budget by $15.3 billion.

The option would take advantage of the ability of Brilliant Eyes to track theater ballistic missiles outside the earth's atmosphere. Such data would improve the performance of area defenses like THAAD by telling its radar where to look for the target and allowing the system to launch its interceptors while the target is still outside of the radar's range. These capabilities will expand the area that these systems will be able to defend. Future theater missile defenses may be able to intercept missiles well beyond the range of the radar based on data from Brilliant Eyes, expanding the defended areas even further.

Nevertheless, Brilliant Eyes will only be useful against theater ballistic missiles with long ranges. Missiles with ranges much less than 1,000

kilometers do not spend much time in space and are within radar range for most area defenses for much of their trajectory. If long-range theater ballistic missiles are unlikely to proliferate to the developing world, Brilliant Eyes may not be a wise investment. Canceling the program also avoids the issues of treaty compliance that a midcourse sensor could raise. Finally, canceling the sensor program would reduce some of the overlap in space-based sensors that the Congress has identified in recent years.

Option IV: Increase Funding for Advanced Theater Missile Defense Systems

Some supporters of theater missile defense have criticized the Administration's plan for not spending enough on active defenses. Option IV would accelerate the development of the three advanced-capability theater missile defense systems (Corps SAM, sea-based upper-tier defense, and boost-phase intercept) by increasing the funding for those programs by $200 million per year through 2010. All other funding would remain the same as in the Administration's plan. Because detailed spending plans for the sea-based upper-tier defense and boost-phase interceptors are not available, this option does not specify how the extra money would be spent. It could be used to accelerate the development of one system or speed up work on all three to a lesser extent.

Option IV offers the obvious benefit of providing more capable defenses earlier than planned by the Administration. Having more types of defenses at their disposal sooner will give U.S. commanders more flexibility during a contingency. They could opt to deploy land-based systems, or keep a lower profile by deploying sea-based systems to protect allied populations and key embarkation points for U.S. forces. Similarly, they could opt to deploy boost-phase defenses if the adversary possesses ballistic missiles armed with unconventional weapons or submunitions. A combination of all these systems might be better able to protect U.S. forces if ballistic missiles and weapons of mass destruction proliferate more quickly than the Administration anticipates.

However, getting these capabilities earlier comes at a price that may not be acceptable in the current climate of austere budgets. Furthermore, the extra funding required for this option would have to come from other DoD programs or elsewhere in the Ballistic Missile Defense Organization budget unless the total DoD budget were increased. Finally, accelerating the development of these programs could raise compliance issues with the ABM treaty earlier than the Administration's plan unless the Administration successfully convinces Russia (and the Senate) to accept its proposal that 5 kilometers per second be the dividing line between theater and strategic ballistic missiles.

CHAPTER I

INTRODUCTION

When Iraq attacked Israel and Saudi Arabia with Scud missiles during the Persian Gulf War, it forced leaders in the United States to recognize that such ballistic missiles could be a factor in future regional conflicts. From that conflict arose a broad consensus in the Congress that U.S. forces should be better protected against those threats. As a result, the Congress has significantly increased the resources for developing theater ballistic missile defenses since the war. The war also demonstrated that the United States must work to prevent the spread of ballistic missiles.

There has been less agreement, however, about how much protection is enough. Some Members of Congress want to take a limited approach--deploy a few types of defenses, mostly by upgrading existing systems. Others want to develop as many means as possible to confront this vexing problem. What is sufficient depends on one's assessment about the extent of the threat posed by theater ballistic missiles to U.S. forces and allied populations. That, in turn, depends on what one thinks about the degree to which proliferation of theater ballistic missiles and weapons of mass destruction will occur. It also depends on how adequate one believes the United States' conventional and nuclear forces are for deterring attacks by these weapons.

In the view of those who want to take a limited approach, the Administration is planning to squander too much to counter a threat of limited concern to U.S. forces. For example, U.S. commanders did not consider Iraq's theater ballistic missiles to be an effective military weapon during the Persian Gulf War--the missiles were inaccurate, and the damage from the high-explosive warhead was limited. Furthermore, ballistic missiles are expensive, and inventories throughout the developing world are relatively small. Iraq was unable to launch many of them--only 88 in five weeks compared with the 3,000 V-2 missiles (a similar weapon) that the Germans launched at Britain and Belgium during a period of about seven months in 1944 and 1945. In addition, they argue, no regional adversary is going to be capable of locating and targeting U.S. forces in the face of superior U.S. air power. They also contend that the United States' strong conventional forces and its nuclear weapons should be sufficient to deter an adversary from using weapons of mass destruction. For example, those deterrents might explain why Iraq did not use any of its large chemical arsenal against U.S. forces, Israel, or Saudi Arabia.

Iraq demonstrated that theater ballistic missiles were primarily political weapons; it aimed most of its weapons at population centers. Advocates of the limited approach to theater missile defenses (TMD) argue that if protecting populations of U.S. allies in the Middle East, Europe, and Northeast Asia is the primary purpose of the Administration's theater missile defense programs (particularly area defenses), allies should pay for such defenses themselves if they are concerned about the threat. Finally, they contend that active theater missile defenses will never be perfect and will do little, if anything, to protect against weapons delivered by aircraft, cruise missiles, or terrorists.

The military and supporters of the Administration's program largely agree that Iraqi missiles had little military utility, but they take a different view of the future. They project adversaries who have missiles that are effective military weapons--more accurate and possibly armed with chemical, biological, or even nuclear warheads. Furthermore, future adversaries may be able to target U.S. forces with small drone aircraft despite U.S. air superiority.

To supporters of advanced theater missile defenses, such systems can provide U.S. commanders with more freedom of action. First, defenses can help protect U.S. forces and allow them to function effectively against an adversary armed with advanced ballistic missiles. Second, by protecting cities, advanced defenses can counter the effectiveness of ballistic missiles used as political weapons. Attacks against urban areas can affect military operations because they may force the military to divert assets to hunt for mobile missile launchers--assets that could be used more productively elsewhere. Allied air forces devoted large numbers of missions to the anti-V-2 campaign during World War II. Iraqi mobile missiles caused a similar diversion during the Persian Gulf War. Third, allied nations may be more willing to accept U.S. forces on their soil if they know that U.S. forces can help protect their cities from ballistic missile attacks.

The Administration now has a significant program in place to develop theater ballistic missile defenses. Managed and funded for the most part by the Ballistic Missile Defense Organization (BMDO)--the successor to the Strategic Defense Initiative Organization--this effort now involves all four services. The Administration's program is based on a conceptual framework that is built on four "pillars." Active defenses shoot missiles out of the sky with systems like the Patriot. Passive defenses, such as protective clothing and bomb shelters, minimize the effects of missiles that penetrate the active defenses. Attack operations seek to disrupt or destroy an adversary's ability

to launch ballistic missiles. And command and control systems allow the other three pillars to function effectively together.

Together, those four pillars of theater missile defenses--including related space-based sensors--will consume some $2 billion in 1994--$1.8 billion in the BMDO budget and $200 million from other theater missile defense efforts outside BMDO. The Administration has requested another $2.7 billion for 1995 and has budgeted more than $14 billion over the next five years. Budget requests for those activities through 2010 are expected to total $50 billion. (All costs in this paper are expressed in 1995 dollars of budget authority.)

A significant fraction of this $50 billion will be devoted to active defenses. The second most expensive component of the Department of Defense's (DoD's) plan will be the space-based sensors for detecting and tracking theater ballistic missiles that the Administration is developing to improve its command, control, communications, and intelligence (C^3I) capabilities. Passive defenses are relatively inexpensive, and although more could be spent on them, it would still be small compared with what is spent on active defenses. Attack operations are also relatively inexpensive, at least in the short run. Many of the forces necessary to conduct them are already part of the U.S. force structure or are being developed for other missions. What is required now is better coordination among existing forces and sensors. In the long run, better sensors and techniques to detect and track mobile missile launchers will be required as well as command, control, and communications systems to relay this data to the forces involved.

Of course, the best way to protect U.S. forces and allies from theater ballistic missiles is to prevent their proliferation in the first place. If ballistic missiles are not present in a region, they cannot be a threat. Through export controls, multilateral treaties, and supplier cartels, the United States can attempt to reduce the proliferation of ballistic missiles as well as the nuclear, biological, and chemical (or so-called unconventional) weapons that they can carry. It can also work to reduce the regional instabilities that create a demand for these weapons by instituting confidence-building measures, providing security assistance and guarantees, helping to mediate disputes, and encouraging regional powers to eliminate their arsenals.

The Administration is pursuing all of these paths to some degree. It has established a new standing committee within the purview of the National Security Council that will coordinate policies throughout the executive branch aimed at halting proliferation. Within the Department of Defense, the new Counterproliferation Initiative encompasses efforts to control proliferation and protect forces in instances where an adversary already has weapons of mass

destruction. Theater missile defenses--including active defense, passive defense, and attack operations--are part of this effort, but only as they relate to weapons of mass destruction. The Administration is also working hard to ensure that nuclear weapons from the states of the former Soviet Union are dismantled.

Despite all the active defenses, attack operations, and proliferation controls that the Administration is pushing, protecting against theater ballistic missiles will remain a challenging problem. The further spread of unconventional weapons will only aggravate the problem. Judging by the difficulty that U.S. forces had in hunting Scud launchers during the Persian Gulf War, it may be even more difficult to develop the means for conducting effective attack operations. Consequently, in the future, U.S. forces could be subjected to chemical, nuclear, or biological weapons that penetrated U.S. defenses or were delivered by other means--a possibility that U.S. leaders and commanders will have to face. Such realities will affect their calculus when planning to fight another regional war.

CHAPTER II

INTRODUCTION TO ACTIVE THEATER BALLISTIC MISSILE DEFENSES

Active theater ballistic missile defenses are complex systems. Understanding the basic elements of theater ballistic missiles and ballistic missile defenses, however, is important to follow the Administration's plan and the alternatives to it.

THE TRAJECTORY OF A BALLISTIC MISSILE

Launching a ballistic missile is like throwing a baseball: the rocket, like an arm, lofts the warhead or baseball into the air. Once the rocket stops burning (or the ball leaves the arm), the ball follows a predictable parabolic trajectory subject only to the force of gravity and air resistance. How far the ball goes (its range) depends on how hard and at what angle it is thrown. For any given arm strength (missile size) and ball weight, there is a launch angle that results in the maximum range. This angle is between 35 degrees and 45 degrees for theater ballistic missiles; for missiles with intercontinental ranges, it is closer to 25 degrees. Although throwing the ball at a lesser angle will result in a shorter range, this technique could be used to fly below defenses that are ineffective below some minimum altitude.

A ballistic missile has three distinct phases to its flight. The boost phase begins at launch and ends when the missile motor stops burning. For theater ballistic missiles, this phase typically lasts between 30 and 120 seconds, depending on the range and type of the missile (see Figure 1). It usually ends when the missile has reached an altitude of approximately 60 to 120 kilometers, near the limits of the earth's atmosphere or above it altogether.

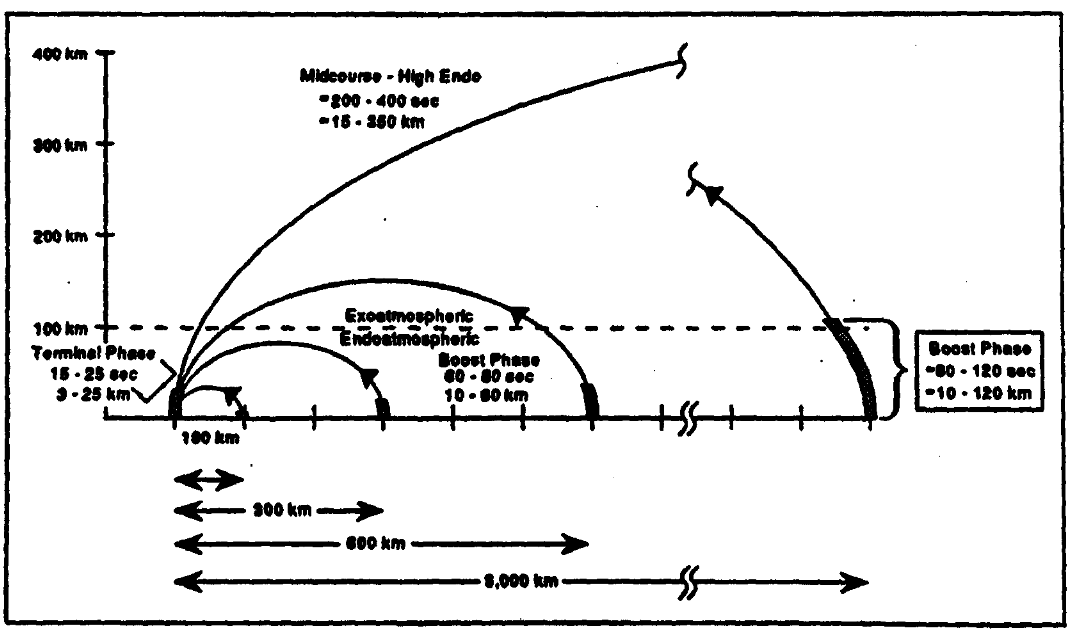
The midcourse phase begins after the missile motor burns out and ends when the missile begins to reenter the atmosphere. Since it occurs mostly outside the atmosphere, the missile simply coasts, subject only to the force of gravity. During midcourse, the missile reaches its maximum altitude. If the missile's range is so short that it does not leave the atmosphere, there really is no midcourse phase. In fact, most theater ballistic missiles have maximum ranges short enough that they spend very little time outside the atmosphere. For a Scud-B with a 300 kilometer range, midcourse lasts a few seconds. In contrast, an intercontinental ballistic missile spends more than 25 minutes outside the atmosphere while traveling 10,000 kilometers.

The final, or reentry, phase begins when the warhead (and the missile, if it is still attached) begins to reenter the earth's atmosphere at an altitude of roughly 80 to 100 kilometers. During reentry, the warhead heats up as it is buffeted by an increasingly dense atmosphere.

TYPES OF BALLISTIC MISSILES AND WARHEADS

Ballistic missiles are typically classified by range. Intercontinental or strategic missiles have ranges that are on the order of 10,000 kilometers. Intermediate-range ballistic missiles have ranges of 1,000 to 5,500 kilometers. Short-range ballistic missiles are those with ranges less than 1,000 kilometers. This latter group and intermediate-range missiles that travel less than 3,500 kilometers or so are often called theater ballistic missiles. Theater ballistic missile defenses are designed to provide defense against missiles with such ranges. These classifications are somewhat arbitrary and the subject of debate (particularly the dividing line between theater and strategic missiles), but will be used for the purposes of this study.

FIGURE 1. THE PHASES OF BALLISTIC MISSILE FLIGHT



SOURCE: Ballistic Missile Defense Organization, *1993 Report to Congress on the Theater Missile Defense Initiative (TMDI)* (Washington, D.C.: BMDO, 1993), p. 2-3.

According to published reports, a variety of missiles are deployed in the developing world, most with ranges of 300 kilometers or less (see Table 1). Roughly 13 countries in the developing world possess missiles in this category. Except for Taiwan, all of these countries are located in the Middle East, the Indian subcontinent, or the Korean peninsula. The Scud-B is the most common type, possessed by eight of the thirteen countries. Four of these countries (Afghanistan, Saudi Arabia, Syria, and Yemen) have no capability to produce ballistic missiles indigenously; they must rely on imports.

Less common are missiles with ranges between 300 and 900 kilometers. Only five of the thirteen countries mentioned above have deployed missiles of this type, and all of them have ranges on the order of 500 to 600 kilometers. One example is the enhanced Scuds such as the Al Hussein used by Iraq during the Persian Gulf War. In its report on the National Defense Authorization Act for Fiscal Year 1995, the House Armed Services Committee cites data from the Department of Defense that 97 percent of the threat from theater ballistic missiles is from those with ranges of 1,000 kilometers or less.

Only two countries outside the North Atlantic Treaty Organization, the former Soviet Union, or China have deployed missiles with ranges greater than 900 kilometers: Israel and Saudi Arabia. Both of these states are allies of the United States. Approximately 50 Chinese CSS-2 missiles were sold to Saudi Arabia. But these are the only ones that exist outside China, and China has since agreed to adhere to the limits of the Missile Technology Control Regime that forbid further exports of that missile. However, three more countries are reportedly developing such missiles. India has developed and tested at least once a missile called the Agni, with a range reportedly on the order of 2,500 kilometers. North Korea is developing the No Dong missile, which has been tested but over less than its full range. The No Dong has not yet been deployed or exported. In addition, recent public statements by the Central Intelligence Agency have indicated that North Korea is in the early stages of developing two missiles with ranges greater than 1,000 kilometers and perhaps as long as 3,500 kilometers. Those missiles have been dubbed Taepo Dong.

Recent discussions about theater ballistic missiles and the Anti-Ballistic Missile (ABM) Treaty have focused on the maximum speed of missiles. (See Table 2 for the speeds and flight times of some commonly discussed theater ballistic missiles: the Frog-7, Scud-B, Al Hussein, No Dong, and CSS-2.)

TABLE 1. BALLISTIC MISSILES IN THE DEVELOPING WORLD

Missile	Quantities: Range (Kilometers)	Quantities: Payload (Kilograms)	Countries
	Missiles with Ranges of 300 Kilometers or Less		
Operational			
Hatf I	80	500	Pakistan
Ching Feng	100	275	Taiwan
SS-21	120	450	Syria, Yemen
Mushak-120/160	120/160	500/N.A.	Iran
Lance	130	275	Israel
Prithvi	150/250	1,000/500	India
NHK-1	180	500	South Korea
8610	300	500	Iran
Scud-B	300	1,000	Afghanistan, Egypt, Iran, Iraq, Libya, North Korea, Syria, Yemen
Under Development			
Laith (Tested)	90	500	Iraq
Alacran	200	500	Argentina
Mushak-200	200	N.A.	Iran
NHK-2 (Tested)	260	450	South Korea
Hatf II (Tested)	300	500	Pakistan
	Missiles with Ranges Between 300 and 900 Kilometers		
Operational			
Scud-C	500	700	Iran, North Korea, Syria
Al Hussein	600	500	Iraq
Jericho I	650	500	Israel
Under Development			
Hatf III	600	<1,000	Pakistan
Scud-100	600	500	Egypt
Al Fateh	<950	500	Libya
	Missiles with Ranges Greater than 900 Kilometers		
Operational			
Jericho II	1,500	500	Israel
CSS-2	2,700	2,200	Saudi Arabia
Under Development			
Tondar-68	1,000	500	Iran
No Dong-1 (Tested)	1,000	1,000	North Korea
No Dong-2	<2,000	<1,000	North Korea
Agni (Tested)	2,500	1,000	India
Taepo Dong-1 and -2	>1,000[a]	N.A.	North Korea

SOURCE: Congressional Budget Office based on Arms Control Association, "The Global Proliferation of Theater Ballistic Missiles," *Arms Control Today* (April 1994), pp. 30-31; Duncan S. Lennox, ed., *Jane's Strategic Weapons Systems* (Surrey, U.K.: Jane's Information Group, 1993); International Institute for Strategic Studies, *The Military Balance 1992-1993* (London: Brassey's, 1992); "Missile and Space Launch Capabilities of Selected Countries," *The Nonproliferation Review*, vol. 1, no. 1 (Fall 1993), pp. 56-59; and Robert G. Nagler, *Ballistic Missile Proliferation: An Emerging Threat* (Arlington, Va.: System Planning Corporation, 1992).

NOTES: The table excludes Frog-7 missiles and other unguided rockets as well as missiles deployed in North Atlantic Treaty Organization countries, states of the former Soviet Union, China, and Eastern Europe. N.A. = not available. < = less than; > = more than.

a. The Central Intelligence Agency recently announced that North Korea is in the early stages of developing two new missiles with ranges greater than 1,000 kilometers. According to one report, their ranges could be as long as 2,000 to 3,500 kilometers.

TABLE 2. CHARACTERISTICS OF COMMONLY DISCUSSED THEATER BALLISTIC MISSILES

System	Country	Status	Range (Kilometers)	Payload (Kilograms)	Time of Flight (Minutes)	Maximum Reentry Speed[a] (Km/sec)
Frog-7[b]	Many	Operational	70	450	2	0.9
Scud-B	Many	Operational	300	1,000	4	1.5
Al Hussein	Iraq	Operational[c]	600	500	6	2.2
No Dong-1	North Korea	Tested	1,000	1,000	8	2.9
CSS-2	Saudi Arabia	Operational	2,700	2,200	14	4.6

SOURCE: Congressional Budget Office based on Arms Control Association, "The Global Proliferation of Theater Ballistic Missiles," *Arms Control Today* (April 1994), pp. 30-31; Duncan S. Lennox, ed., *Jane's Strategic Weapons Systems* (Surrey, U.K.: Jane's Information Group, 1993); and "Missile and Space Launch Capabilities of Selected Countries," *The Nonproliferation Review*, vol. 1, no. 1 (Fall 1993), pp. 56-59.

a. Reentry speeds are approximate and depend on the altitude at which speed is measured. This table assumes that maximum reentry speed occurs at an altitude of roughly 40 kilometers. At this height, the atmosphere is dense enough to slow the reentry vehicle down by enough to offset the pull of gravity.

b. The Frog--which is an unguided rocket--is not usually considered a theater ballistic missile, a term that is commonly reserved for guided ballistic missiles. It is included here for comparison.

c. Under the terms of the United Nations resolution ending the Persian Gulf War, Iraq was required to destroy all ballistic missiles with ranges greater than 150 kilometers. Reports suggest that Iraq may still possess some of these missiles.

Theater ballistic missiles can carry a variety of warheads. Those used in the Gulf War had conventional explosives. The United States has deployed theater missiles with nuclear and chemical warheads as well, although those have largely been dismantled. According to published reports, few countries in the developing world possess nuclear weapons. More possess chemical weapons. In addition, growing evidence indicates that several countries are developing biological weapons.[1]

Conventional warheads come in two varieties. Unitary warheads concentrate a large explosion on one small area; clustered submunitions spread smaller explosions over a larger area. Clustered submunitions concern

1. See, for example, Steve Fetter, "Ballistic Missiles and Weapons of Mass Destruction: What Is the Threat? What Should Be Done?" *International Security*, vol. 16, no. 1 (Summer 1991), p. 14.

ballistic missile defense planners because they can be released beyond the range of some defenses and saturate the defense by creating more targets than it can handle. Chemical and possibly biological weapons could also be deployed in submunitions.

TYPES OF ACTIVE THEATER BALLISTIC MISSILE DEFENSES

Several types of active defenses are available, each designed to destroy a ballistic missile at a specific phase of its trajectory. Boost-phase defenses would intercept missiles during the first phase of their journey. Since they have only a minute or so to act, they must be located near the missile (within 100 to 200 kilometers or so, depending on how fast the interceptors are) and be able to react very quickly. To date, no country has deployed a boost-phase defense.

Terminal defenses--such as the Patriot and the Theater High Altitude Area Defense (THAAD)--are designed to intercept missiles as they reenter the atmosphere. The Patriot Advanced Capability, Level 3 (PAC-3), will be designed to intercept missiles up to altitudes of about 25 to 30 kilometers. Because it functions in the lower regions of the atmosphere, it is called a lower-tier defense. THAAD will be able to intercept missiles in the upper part of the atmosphere and outside it altogether, or at altitudes from about 30 to several hundred kilometers. Thus, it is called an upper-tier defense. THAAD is the only system currently planned by the Administration that would function in both the reentry and midcourse phases. An exoatmospheric system such as the Navy's Standard missile tipped with the Lightweight Exoatmospheric Projectile (LEAP)--which has been proposed for the Navy's area defense--would only be able to intercept missiles above 80 to 100 kilometers. Thus, it is almost exclusively a midcourse system.

The area that a particular system can defend depends on several factors: the size of its radar, the speed of its interceptors, and the support that it receives from external sensors. In addition, the area that a system can defend is not the same in every scenario; the range of the missile (and thus its speed) that it is defending against will also affect the size of the defended area. The number of missiles that it must face simultaneously can also affect the size of the area that it can protect. Countermeasures that clutter the sky with false targets can have the same effect.

To illustrate the effect of missile range on a defense, suppose that an upper-tier defense similar to THAAD could protect an area of 240,000 square kilometers against a 600-kilometer-range Al Hussein traveling about 2.2

kilometers per second. The same system may only be able to defend 20 percent of this area against a missile with a 3,000 kilometer range and a speed of roughly 4.7 kilometers per second (see Figure 2).[2] All of the illustrations of capability in this paper are based on a model that the Ballistic Missile Defense Organization provided to the Congressional Budget Office (CBO). Of course, the results reflect CBO's assumptions about the capabilities of each system. A lower-tier defense similar to PAC-3 would experience a comparable result. The area that it could defend against a missile with a 300 kilometer range would be larger than what it could defend against a missile with a 600 kilometer range (see Figure 3).[3] However, it would have virtually no capability against a 3,000 kilometer missile.

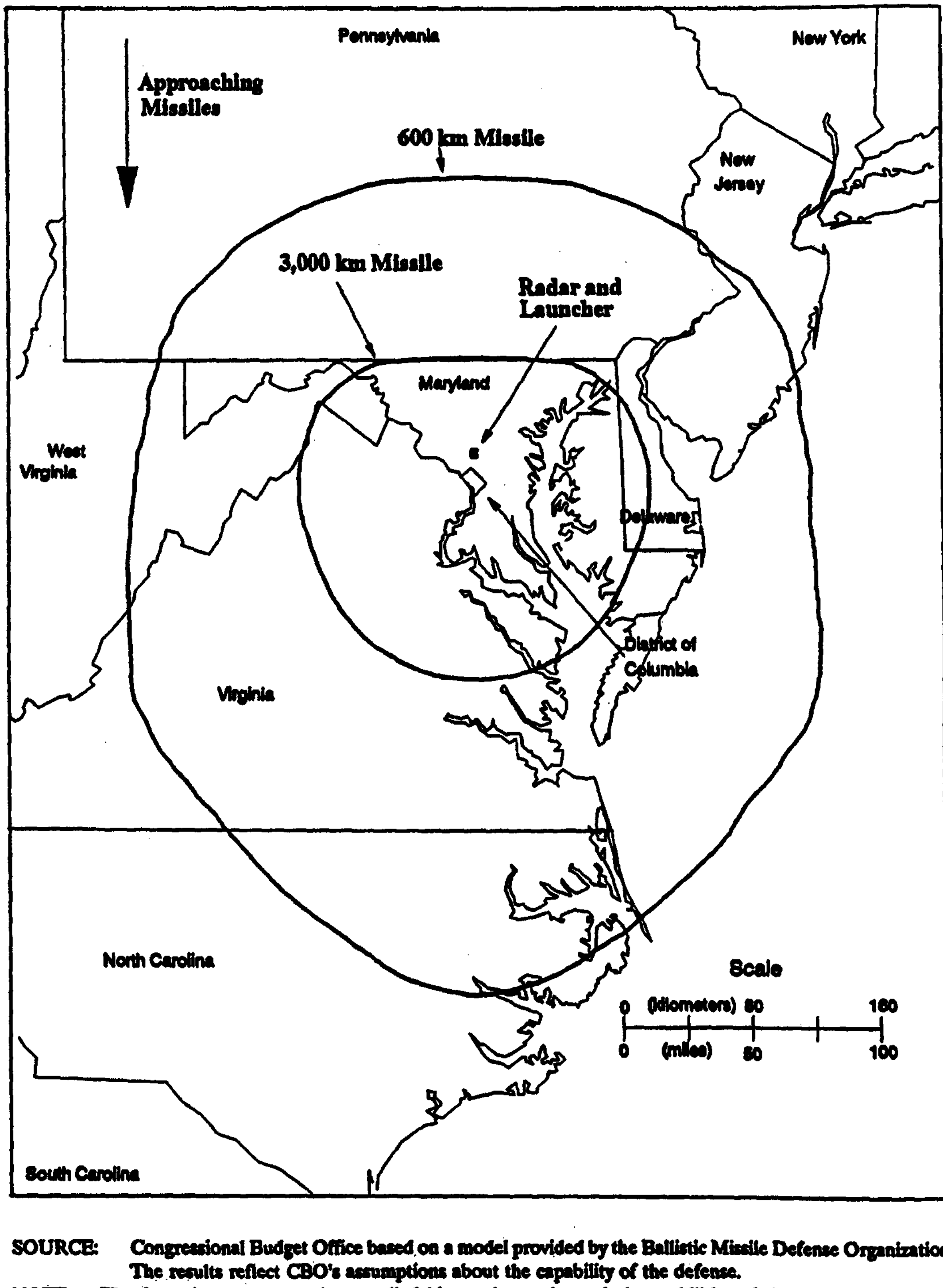
One must use footprint calculations such as the ones in Figures 2 and 3 and those that are used elsewhere in this paper with caution, however. They represent the so-called kinematic--or theoretical--capabilities of the system and do not reflect the probability that an incoming warhead will be destroyed. In other words, they show only that the interceptor has the ability to fly out to the point in space required to make the intercept but not whether it is capable of destroying the warhead once it gets there. The probability that an interception will occur is certainly less than one and should vary throughout the footprint. It depends on the capabilities of the interceptor's kill vehicle and also on the scenario--the angle at which it intercepts the target, the type of countermeasures, and the number of incoming warheads. Thus, the footprints shown in Figures 2 and 3 illustrate the area that could be protected in the best case for the given assumptions.

Terminal defenses can be deployed on ships or based on land. The Navy has proposed area and point missile defenses based on its Aegis air defense ships. Those systems would be similar to the land-based defenses being built by the Army, and they would function in much the same way. However, sea-based defenses can be deployed over much of the oceans and in most coastal areas of the globe. They can defend U.S. forces during amphibious landings or protect critical logistics nodes, command centers, or population centers that are located near the coast. Sea-based defenses can

2. This simulation assumes that the interceptor has a peak speed of 2.6 kilometers per second, a specific impulse of 270 seconds, and a mass ratio of 3.25; burns out after 17 seconds; and functions at altitudes above 40 kilometers. The radar has a range of 500 kilometers, must track the incoming missile for 10 seconds before it launches its first interceptor, and must see the interception.

3. This simulation assumes that the interceptor has a peak speed of 1.7 kilometers per second, a specific impulse of 230 seconds, and a mass ratio of 2.6; burns out after 12 seconds; and functions at altitudes from 2 to 40 kilometers. The radar has a range of 90 kilometers, must track the incoming missile for 10 seconds before it launches its first interceptor, and must see the interception.

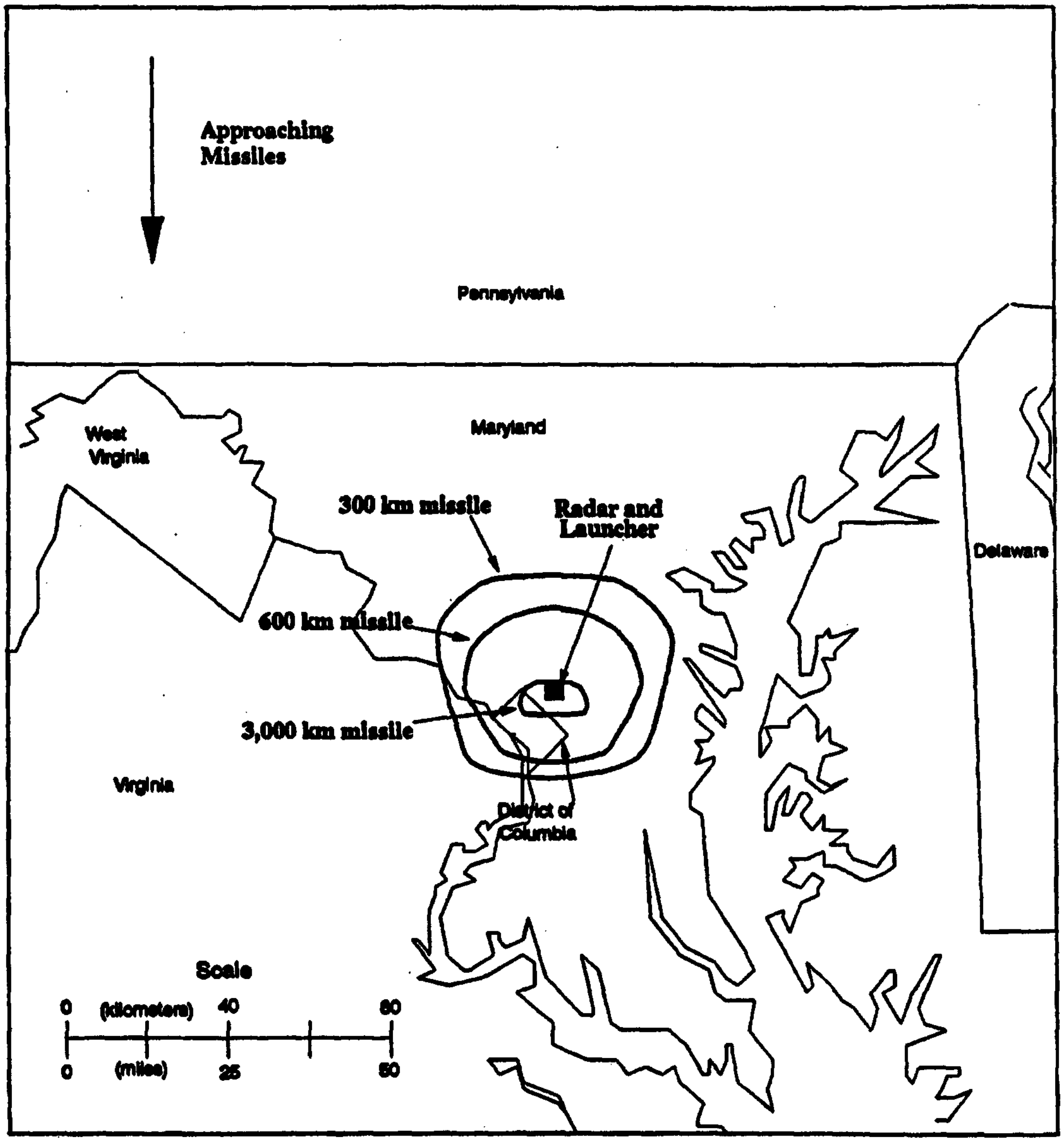
FIGURE 2. THE EFFECT OF MISSILE RANGE ON THE AREA DEFENDED BY AN ILLUSTRATIVE UPPER-TIER DEFENSE



SOURCE: Congressional Budget Office based on a model provided by the Ballistic Missile Defense Organization. The results reflect CBO's assumptions about the capability of the defense.

NOTE: The footprints represent the so-called kinematic--or theoretical--capabilities of the system and do not reflect the probability that an incoming warhead will be destroyed. The probability that an interception will be successful is certainly less than one and should vary throughout the footprint. It depends on the capabilities of the interceptor's kill vehicle and also on the scenario--the angle at which the interception occurs, the type of countermeasures, and the number of incoming warheads. The map of the Middle Atlantic states is shown to give perspective to the footprint sizes. It does not imply that the United States would be attacked by theater ballistic missiles.

FIGURE 3. THE EFFECT OF MISSILE RANGE ON THE AREA DEFENDED BY AN ILLUSTRATIVE LOWER-TIER DEFENSE



SOURCE: Congressional Budget Office based on a model provided by the Ballistic Missile Defense Organization. The results reflect CBO's assumptions about the capability of the defense.

NOTE: The footprints represent the so-called kinematic--or theoretical--capabilities of the system and do not reflect the probability that an incoming warhead will be destroyed. The probability that an interception will be successful is certainly less than one and should vary throughout the footprint. It depends on the capabilities of the interceptor's kill vehicle and also on the scenario--the angle at which the interception occurs, the type of countermeasures, and the number of incoming warheads. The map of the Middle Atlantic states is shown to give perspective to the footprint sizes. It does not imply that the United States would be attacked by theater ballistic missiles.

also be deployed between an attacker and the targeted country if those nations are separated by the sea. Such scenarios might occur during an attack by North Korea on Japan or by Iraq on Europe. In this case, the area defended would be much larger than the area that could be protected by a ground- or sea-based defense located in or near the country being attacked.

COMPONENTS OF ACTIVE THEATER BALLISTIC MISSILE DEFENSES

Theater missile defenses have several basic elements in common: a sensor, a launcher, an interceptor (equipped with a seeker and a kill vehicle or warhead), and a command and control center. The sensor, usually a radar, detects incoming missiles and guides the interceptors to the intercept point. In terminal defenses, the radar is ground based; it is likely to be aircraft based in boost-phase defenses. The launcher houses the interceptors and launches them on command. Interceptors fly toward the estimated intercept point, as calculated by the command and control center based on data from the radar. As the interceptor flies out, it receives updated information about the target from its command and control center to get it closer to the correct intercept point. Once the interceptor gets close to the target, its onboard seeker is activated to guide it to the intercept point. The radar and external sensors must get the interceptor close enough to allow its own seeker to take over.

Tracking data can come from other sources than the radar associated with a particular launcher. For example, early-warning sensors can tell terminal defenses that a missile is headed toward them and tell their ground-based radar where to look for the incoming warhead. Space-based sensors that track the missile during midcourse can also provide course updates.

A command and control system connects all the components of the different defenses. It links early-warning sensors with missile defense batteries and directs specific batteries and types of defenses (lower-tier, upper-tier, and boost-phase) to engage specific targets.

PUTTING THE COMPONENTS TOGETHER: THE EFFECT OF LAYERS

One of the challenges of developing defenses against theater ballistic missiles is to make them relatively impervious to leaks. (The number of leaks depends in large part on the size of the attack and the ability of the attacker to deploy countermeasures.) Meeting this goal with a single defense system

is a great challenge because the effectiveness of any single type of weapon system is rarely greater than 90 percent, even for well-established systems; numbers such as 40 percent to 80 percent are far more common. For example, the only theater missile defense that has been tested in combat--the Patriot PAC-2 of Persian Gulf War fame--had an effectiveness of 40 percent in Israel and 70 percent in Saudi Arabia, according to the Army. Critics claim that it was much lower.

The overall effectiveness of the system is a product of several factors: the probability that the system will detect the incoming missile, the reliability of the missile (whether it launches properly and flies to the appropriate point in space), and the probability that the sensor on the missile will find the target and guide the kill vehicle to a successful interception. If each one of these probabilities is 0.9 (a high level by most measures), the overall system effectiveness would be 73 percent ($0.9 \times 0.9 \times 0.9 = 0.73$). If each probability is 0.8, the overall effectiveness falls to just 50 percent.

Unlike this simple illustration, however, the effectiveness of a system is not well defined; it depends strongly on the nature of the attack and varies throughout the area defended by that particular system. Countermeasures such as decoys can reduce the probability that an actual warhead will be detected and destroyed. Similarly, a large attack aimed at a small area can overwhelm the defense. The type of warhead can also play a role. For example, a warhead with chemical or biological submunitions may be more difficult to destroy completely than a standard warhead with high explosives.

Nevertheless, to illustrate what the effectiveness of a system means, assume that 10 missiles attack an airfield protected by a single Patriot PAC-3 battery. With a 70 percent system effectiveness, an average of three missiles would penetrate the defenses. Five would penetrate with a system effectiveness of 50 percent (see Table 3).

Although these probabilities seem low, they are better than the 40 percent effectiveness that the Army says it experienced with the PAC-2 system in Israel during the Persian Gulf War. (Because the Patriot launched a salvo of two interceptors at almost every incoming missile, each interceptor would have to have a kill probability of roughly 20 percent to achieve a 40 percent system effectiveness (see below). Critics have contested the Army's claim, saying that publicly available data suggest that Patriot was much less

TABLE 3. ILLUSTRATION OF THE EFFECTIVENESS OF LAYERED DEFENSES AGAINST AN ATTACK BY 100 THEATER BALLISTIC MISSILES

Type of Layering	Assumed Effectiveness of Each Interceptor[a] (Percent)	Combined Effectiveness[b] (Percent)	Surviving Warheads (Per 100 missiles)	Interceptors Expended (Per 100 warheads)
One Layer, Single Shot				
Less effective	50	50	50	100
More effective	70	70	30	100
One Layer, Two-Shot Salvo	50	75	25	200
One Layer, Shoot-Look-Shoot	50	75	25	150
Two Layers, Single Shot In Each Layer	50	75	25	150
Two Layers: Upper Layer Uses Shoot-Look-Shoot, Lower Layer Uses Single Shot	50	88	12	175

SOURCE: Congressional Budget Office.

a. The effectiveness for each layer is based on a single interception attempt. Fifty percent effectiveness is used here for illustrative purposes only. It does not reflect a judgment by CBO about the effectiveness of any particular system. Actual values could be higher or lower and for a given system would vary according to the type of missile, warhead, countermeasures, and size of the attack.

b. Combined effectiveness applies only to the area protected by all layers and all shots within a layer.

effective.[4] For example, the General Accounting Office reported that data from the war supports at best an effectiveness of 10 percent.[5] Given that the PAC-3 will be designed specifically for the TMD mission, its effectiveness should be somewhat higher.

For illustrative purposes below, the Congressional Budget Office assumes a system effectiveness of about 50 percent for the PAC-3 firing one missile, which is higher than what the Army claims for the PAC-2 and significantly higher than what its critics claim. CBO's assumption does not imply, however, that the actual effectiveness of the PAC-3 system would be 50 percent. It could be higher or lower and would depend on the exact

4. See, for example, George N. Lewis and Theodore A. Postol, "Video Evidence on the Effectiveness of Patriot During the 1991 Gulf War," *Science and Global Security*, vol. 4 (1993), pp. 1-63.

5. General Accounting Office, "Operation Desert Storm: Data Does Not Exist to Conclusively Say How Well Patriot Performed," NSIAD-92-340 (1992).

scenario: the range of the missile, the number of missiles in an attack, and the existence of countermeasures.

The most common way to reduce leakage in a defense of any type is to use layers. For example, the Navy has used this concept to protect its battle groups from attack by hostile submarines and aircraft. In principle, the first layer tries to intercept the missiles passing through it. Subsequent layers only have to contend with those missiles that survive the previous layers. Expressed in terms of overall effectiveness (assuming an effectiveness of 50 percent for each layer in a two-layer system), the first layer would destroy half of the attacking missiles, and the second layer would destroy half of those surviving the first layer.

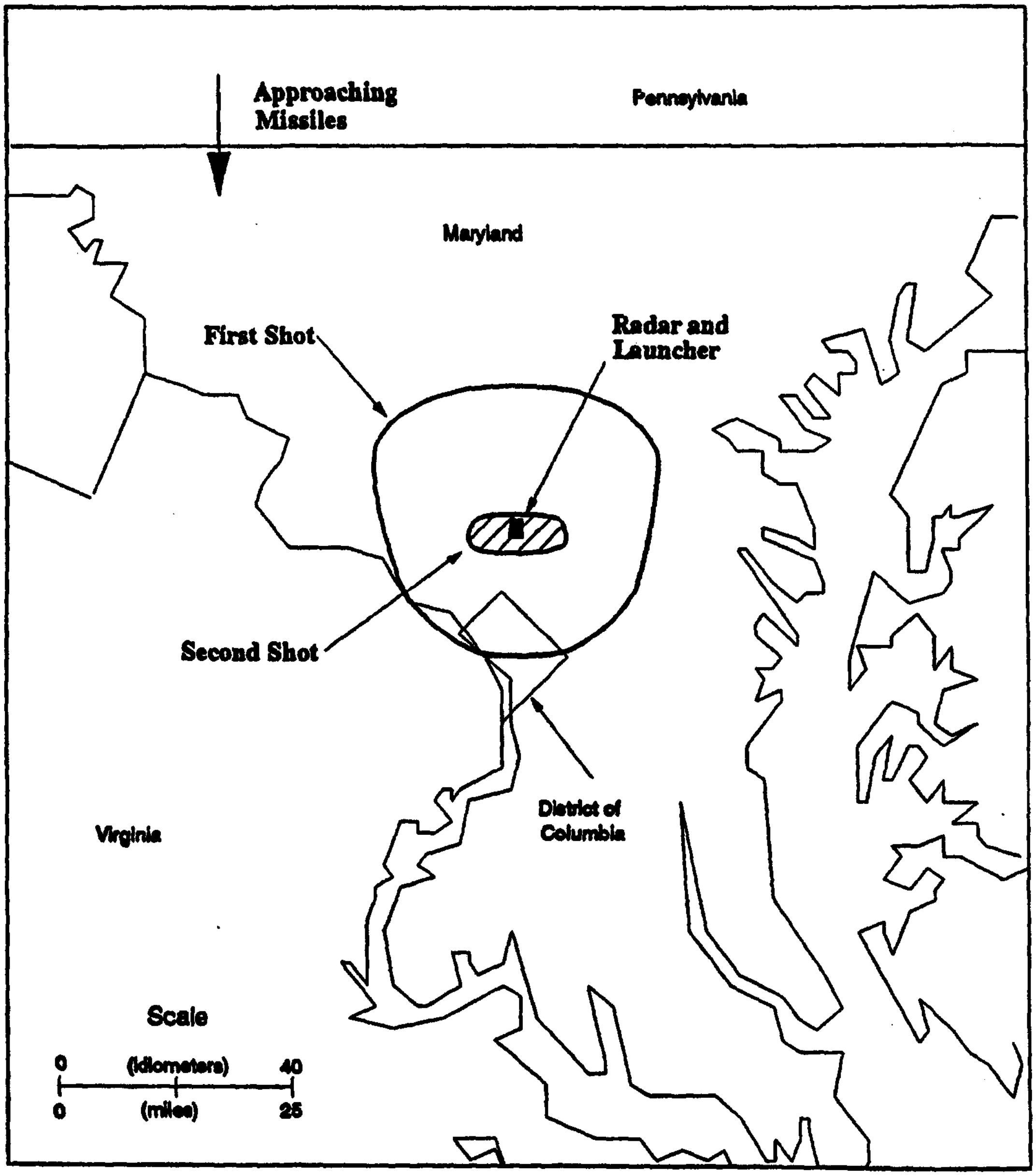
There are several ways to achieve multilayered defenses. An inexpensive approach is to adopt a shoot-look-shoot strategy--launch an interceptor, wait to see if the missile is destroyed, and launch a second interceptor if it survives the first one. In the example of the PAC-3, that strategy would increase the effectiveness to 75 percent (50 percent effective in the first layer and 50 percent effective against the surviving 50 percent in the second). However, point defenses do not have time for such an approach against ballistic missiles traveling at speeds up to 5 kilometers per second. In addition, the second interceptor can protect only a small portion of the area defended by a point defense because it takes time to determine whether the missile has survived the first intercept attempt and then launch another missile (see Figure 4).[6] During that time, the missile has traveled closer to its target.

Because of those difficulties, the tactic that the Army used in the Persian Gulf War was to launch a salvo of two interceptors in rapid succession. It has many of the advantages of a shoot-look-shoot approach, but it can be done more quickly. The disadvantage of this approach is that it wastes interceptors; 50 percent of the time the second interceptor is unnecessary because the first one destroys the incoming missile.

Another approach is to deploy different types of defenses: one that destroys missiles at high altitudes and farther from their targets (an upper-tier or area defense) and one that destroys at lower altitudes the missiles that leak through the upper-tier defense (a lower-tier or point defense). Again, assuming each layer is 50 percent effective, the effectiveness of the two-layer

6. This simulation uses the same assumptions as those in Figure 3. In addition, it assumes that the defense waits for five seconds after the first attempted interception before launching the second interceptor.

FIGURE 4. AREA DEFENDED BY A POINT DEFENSE USING SHOOT-LOOK-SHOOT AGAINST A 600 KILOMETER MISSILE



SOURCE: Congressional Budget Office based on a model provided by the Ballistic Missile Defense Organization. The results reflect CBO's assumptions about the capability of the defense.

NOTE: The footprints represent the so-called kinematic--or theoretical--capabilities of the system and do not reflect the probability that an incoming warhead will be destroyed. The probability that an interception will be successful is certainly less than one and should vary throughout the footprint. It depends on the capabilities of the interceptor's kill vehicle and also on the scenario--the angle at which the interception occurs, the type of countermeasures, and the number of incoming warheads. The map of the Middle Atlantic states is shown to give perspective to the footprint sizes. It does not imply that the United States would be attacked by theater ballistic missiles.

system would be 75 percent (see Table 3 on page 16). However, this calculation would only hold for the limited areas protected by both the area and the point defense. For example, typical Army doctrine would provide point defenses only around critical targets toward the rear of the theater. Thus, large areas would be protected by only an upper-tier defense. Also, a shorter-range missile could fly too low for an upper-tier defense to intercept it. In this case, a point defense may provide the only protection.

Nevertheless, the area protected by both layers of this system would be much larger than in the shoot-look-shoot case for a point defense. In addition, an upper-tier defense could provide defense against some unconventional weapons and conventional submunition warheads that otherwise might detonate or disperse above the maximum altitude of the point defense. An area defense can also use a shoot-look-shoot strategy to create what is effectively a third layer with an effectiveness of 88 percent if one assumes that each attempt to intercept the target is likely to succeed 50 percent of the time. Against 100 missiles aimed at the small area defended by all three layers, the upper tier could destroy 50 missiles with its first interception attempts and 25 of the surviving missiles with the next 50 attempts. Finally, the point defense would destroy an average of 12.5 of the 25 missiles that survived the upper-layer defense's shoot-look-shoot tactics, giving a total of 88 missiles destroyed, on average, by all three layers. If the missiles were aimed at areas unprotected by the point defense, the effectiveness would be lower. Similarly, boost-phase defenses can provide an additional layer, creating a three-layer defense for those targets protected by all three.

THE EFFECT OF ADDING SPACE-BASED SENSORS

Space-based sensors play an important role in ballistic missile defenses. Early-warning satellites high above the earth detect the hot exhaust fumes from rocket motors. They track the missiles shortly after launch until their rocket motors stop burning. Midcourse sensors--should they be deployed--would allow more accurate tracking of medium- and long-range theater as well as strategic ballistic missiles.

Data from early-warning sensors, especially when combined from two satellites viewing the same missile, allow commanders to estimate the missile's likely target. Such data permit active defenses to focus their radars on the correct portion of the sky and civilians and military forces to take passive defense measures. Early-warning sensors could also alert fighters on patrol carrying boost-phase interceptors that a launch has occurred and tell them

where to look. In addition, U.S. forces can use early-warning data to estimate the approximate location of the missile launch and then direct fighter aircraft to search for and destroy the mobile launcher.

During the Persian Gulf War, the United States was able to use data from two or three early-warning satellites from the Defense Support Program (DSP) to identify which country was under attack. The data typically provided a couple of minutes of warning to the theater before impact. This advanced notice allowed commanders in Saudi Arabia to warn civilians, troops, and Patriot batteries in Israel and Saudi Arabia that an attack was imminent. Commanders also used DSP data to estimate the launch location (reportedly within a radius of 2.2 miles) and then direct fighters to search for the missile launchers. The Air Force plans to develop a new early-warning sensor that will be more capable than DSP in detecting and tracking theater ballistic missiles.

Although midcourse sensors have not yet been deployed, they offer the potential of much more precise tracking than early-warning sensors. Early-warning sensors detect hot objects like burning rockets. But because they look down at the earth, they have difficulty detecting anything that has a temperature similar to or cooler than that of the earth. (It is like trying to see the driver of a car at night while looking directly into the headlights. For early-warning sensors, the warm earth is like a big headlight.) Consequently, early-warning sensors cannot track a missile after its rocket motor burns out.

In contrast, midcourse sensors would be able to track the cool missiles and warheads once they leave the atmosphere by looking at them against the cold background of space. Because they can track the warheads for a longer period of time, midcourse sensors can provide much more accurate tracking data. The more precise data from midcourse sensors would allow command authorities to estimate launch points and impact points more exactly, which at a minimum would tell (or cue) ground-based missile defense radar where to look. Not least, they would isolate the disruptions associated with using passive defense measures to a relatively small area.

Better data could also permit an area defense like THAAD to expand the area that it can defend by launching its interceptors before its radar could detect the incoming warheads. The radar would then only need to see the latter stages of the interception. If the data provided by midcourse sensors were good enough and could be supplied to the interceptor while it was in flight, the interception could occur outside of the radar's view altogether. Such a capability would significantly increase the area that the terminal defense could defend.

CHAPTER III

THE ADMINISTRATION'S PLAN FOR THEATER MISSILE DEFENSES

The Clinton Administration has developed a plan to deploy theater missile defenses over the next two decades that will help protect U.S. forces deployed overseas as well as the populations of U.S. allies.[1] This effort is, for the most part, managed and funded by the Ballistic Missile Defense Organization. The Administration is also pursuing several theater missile defense efforts outside of BMDO.

THE FOUR TMD PILLARS: ACTIVE DEFENSES, PASSIVE DEFENSES, ATTACK OPERATIONS, AND C³I

The Ballistic Missile Defense Organization and the Department of Defense have developed a conceptual framework for TMD that is built on four pillars: active defenses; passive defenses; counterforce (also called attack operations); and the command, control, communications, and intelligence systems necessary to make the other three pillars function effectively. Active defenses--systems like Patriot, the Theater High Altitude Area Defense, and boost-phase interceptors that destroy ballistic missiles after they have been launched--have been the primary emphasis of the Administration's theater missile defense effort to date and the focus of BMDO's activities. Using DoD's conceptual framework as a guide, this paper includes the department's efforts in all four areas in its analysis and costing of the Administration's plan.

Although active defenses receive the lion's share of TMD resources, DoD has begun to increase the attention given to the other three pillars. In particular, former Secretary of Defense Les Aspin created the position of Assistant Secretary of Defense for Nuclear Security and Counterproliferation to coordinate and energize efforts within the Pentagon that focus on all four pillars. (Under Aspin's successor, William Perry, the title of this position has reverted to its previous Assistant Secretary for International Security Policy, although nuclear security and counterproliferation remain an important part of the position's portfolio.)

1. The term "theater missile defense" in this paper encompasses all weapon systems designed to protect against ballistic missiles before or after they have been launched. The Navy uses the term "theater ballistic missile defense" to distinguish defenses against ballistic missiles from its already extensive defenses against cruise missiles. Alternatively, the Air Force incorporates theater missile defense in the concept of "theater air defense" to emphasize that it is just an extension of its traditional air defense role.

The Assistant Secretary oversees the new Counterproliferation Initiative, which has two main objectives: halting the spread of unconventional weapons and their delivery systems, and ensuring that U.S. forces have the means to counter these weapons if they do spread. The Assistant Secretary leads efforts within the Department of Defense to stem the proliferation of nuclear, chemical, and biological weapons as well as the systems like ballistic and cruise missiles that can be used to deliver them. Nonproliferation is not part of the Administration's four TMD pillars, but it is a crucial factor in protecting U.S. forces and allied populations. After all, the best way to protect U.S. forces against attacks by ballistic missiles is preventing the spread of those weapons in the first place. However, halting the spread of technology is difficult.

Countering those weapons that have already spread means providing defenses (both passive and active) against them and having the capacity to destroy or disrupt an adversary's ability to launch its missiles by conducting so-called attack, or counterforce, operations. In the theater missile defense context, counterforce involves destroying missile launchers and critical nodes that support missile-launching operations such as missile stockpiles, command and control systems, transportation networks, and manufacturing facilities. It also involves destroying or disrupting the adversary's ability to produce and use nuclear, biological, or chemical weapons.

In addition to creating a new institutional focus on counterproliferation, DoD has increased its funding in recent years for an effort called Warbreaker. Managed by the Advanced Research Projects Agency, the goal of this project is to increase the ability of U.S. forces to detect and destroy mobile targets like theater ballistic missile launchers in a timely manner. DoD is also requesting funding for several parallel efforts within the Air Force.

ACTIVE THEATER MISSILE DEFENSE AND BATTLE MANAGEMENT

Active theater missile defense is the pillar most often associated with the term theater missile defense. Indeed, except for some work on command, control, communications, and intelligence, this approach has been, and will continue to be, the main focus of DoD efforts and the only focus for the Ballistic Missile Defense Organization. (See Table 4 for a brief listing of all of the active defenses and space-based sensors that the Administration's budget request for 1995 would fund, although not all systems may reach production.)

TABLE 4. ACTIVE THEATER BALLISTIC MISSILE DEFENSE SYSTEMS AND RELATED SPACE-BASED SENSORS CURRENTLY BEING DEVELOPED BY DOD

System	Service	Funding Agency
	Lower-Tier (Point) Defenses	
PAC-2 Upgrades	Army	BMDO/Army
PAC-3 (with ERINT)	Army	BMDO
Corps SAM[a]	Army	BMDO
Navy Lower-Tier Defense	Navy	BMDO
Hawk Upgrades	Marines	BMDO
	Upper-Tier (Area) Defenses	
THAAD (Includes TMD-GBR)	Army	BMDO
Navy Upper-Tier Defense[a]	Navy	BMDO
Arrow	Israel[b]	BMDO/Israel
	Boost-Phase Defenses	
Boost-Phase Interceptor[a,c]	Air Force	BMDO/Air Force
Airborne Laser	Air Force	Air Force
	Space-Based Sensors	
Brilliant Eyes	Air Force	BMDO
ALARM	Air Force	Air Force

SOURCE: Congressional Budget Office based on Department of Defense data.

NOTES: DoD = Department of Defense; PAC = Patriot Advanced Capability; BMDO = Ballistic Missile Defense Organization; ERINT = Extended-Range Interceptor; SAM = Surface-to-Air Missile; THAAD = Theater High Altitude Area Defense; TMD-GBR = Theater Missile Defense Ground-Based Radar; ALARM = Alert, Locate, and Report Missiles.

a. BMDO has designated Corps SAM, the Navy upper-tier defense, and the boost-phase interceptor as advanced-capability TMD systems. In 1998, it plans to select one for further development and production based on guidance from the Joint Chiefs of Staff. If budgets beyond 1999 permit, the other two may be developed later.

b. Israel is developing the Arrow system with substantial financial and technical contributions from the United States.

c. As currently envisioned by the Air Force, the boost-phase interceptor will require a large airborne radar that has yet to be developed.

The Core Package: An Emphasis on Terminal Defenses

The cornerstone of BMDO's plan for active theater missile defenses is a so-called "core" package of theater missile defense systems. It consists of two lower-tier (or point) defenses, one upper-tier (or area) defense, and the battle management and command and control system that will tie them all together.[2] The Ballistic Missile Defense Organization believes that the overall effectiveness that two tiers (or layers) provide justifies developing both point and area defenses.

Lower-Tier Defenses. The first lower-tier system is the Army's Patriot PAC-3, a land-based air defense system designed to protect important military targets at the rear of a theater of operations such as airfields, ports, and command and logistics centers. PAC-3 will be an improved version of the Patriot PAC-2 system that the United States deployed during the Persian Gulf War to protect parts of Israel and Saudi Arabia. The Army recently selected the Extended Range Interceptor (ERINT) over the multimode missile to be the PAC-3 interceptor. The first PAC-3 interceptors will be deployed toward the end of 1998 (see Table 5).

According to the Ballistic Missile Defense Organization, it will cost $3 billion to complete the PAC-3 program in addition to the $1.1 billion already appropriated through 1994 (see Table 5). About $2.3 billion of this sum will purchase 1,500 missiles and pay for modifying 180 launchers and 74 radars. The missile defense agency estimates that deploying the new missile will add $35 million annually to the costs of operating the Patriot system.

The second lower-tier system is based on the Navy's Aegis-class destroyers and cruisers. Like the Patriot system, the sea-based lower-tier defense can protect point targets, but only those that are situated near a seacoast. This ability makes the Navy's lower-tier system a natural choice to protect ports, key areas of coastal cities, and Marine amphibious forces. It uses the Block IV version of the Standard missile that the Navy is in the final stages of developing. To enhance the missile's ability against ballistic missiles, the Ballistic Missile Defense Organization will modify the warhead and fuze--making it the Block IVA Standard missile. To improve the ability of the Aegis SPY-1B radar to detect and track ballistic missiles, BMDO will modify its software.

2. The Bottom-Up Review report included Brilliant Eyes as part of the core TMD package. However, in the months between the completion of that review and the 1995 President's budget, the early-warning system was removed from the core package.

TABLE 5. QUANTITIES AND TOTAL COSTS OF ACTIVE THEATER BALLISTIC MISSILE DEFENSES AND RELATED SENSORS BEING DEVELOPED BY DOD

System	Quantities[a] Missiles	Launchers	Radar	Initial Deployment Date	Cost to Complete[b] (Billions of 1995 dollars)
		Core Systems			
PAC-3 (with ERINT)	1,500	180[c]	74[c]	1998	3.0
Navy Lower-Tier Defense	1,820	50[d]	50[d]	1999[e]	3.8
THAAD (with TMD-GBR)	1,313	80	14	2001[e]	9.1
		Advanced-Capability TMD Systems			
Concept Development of: Corps SAM, Navy Upper-Tier, and Boost-Phase Interceptor	n.a.	n.a.	n.a.	n.a.	2.1
Development and Production of One System[f]	N.A.	N.A.	N.A.	N.A.	11.0
		Related Space-Based Sensors			
Brilliant Eyes	28[g]	n.a.	n.a.	2004[h]	3.3
ALARM	12[g]	n.a.	n.a.	2004[h]	12.1

SOURCE: Congressional Budget Office based on Department of Defense data.

NOTES: DOD = Department of Defense; PAC = Patriot Advanced Capability; ERINT = Extended-Range Interceptor; THAAD = Theater High Altitude Area Defense; TMD-GBR = Theater Missile Defense Ground-Based Radar; ALARM = Alert, Locate, and Report Missiles; SAM = Surface-to-Air Missile; N.A. = not available; n.a. = not applicable.

a. Quantities refer to production items only. Those required for development and testing are not listed here.

b. Costs include research, development, testing, and production; they exclude funds appropriated before 1995 and the costs to operate and support the systems after they have been deployed.

c. To accommodate the new missiles and mission, the Army will modify existing Patriot launchers and radars rather than purchase new ones.

d. The Standard Block IVA missiles will be deployed in existing vertical launchers on about 50 Aegis ships and destroyers by 2000. Radar on these ships will be modified.

e. The Ballistic Missile Defense Organization (BMDO) plans to have a deployable prototype of the THAAD and Navy lower-tier systems that will be available by 1996 and 1997, respectively, for use during a crisis. These will be called User Operational Evaluation Systems (UOES).

f. In 1998, BMDO will select one of the three advanced-capability TMD systems for development and production. The other two may be developed later, if budget constraints beyond 1999 permit. The cost of Corps SAM development and production is listed here; the costs of the others are not available.

g. Figure indicates number of satellites, not missiles.

h. This is the delivery date; deployment dates are unavailable.

BMDO plans to deploy the first Navy lower-tier system in 1999. However, it plans to have a prototype version available as early as the end of 1997 that could be deployed during a crisis. BMDO calls this type of deployable prototype a "user operational and evaluation system" (UOES).

CBO estimates that it will cost $3.8 billion to complete the Navy lower-tier system in addition to the more than $200 million already appropriated through 1994 (see Table 5). Nearly $3 billion of this total amount will purchase 1,820 missiles and modify Aegis radars and combat systems, according to BMDO. It has not released estimates of the costs to operate this system once it has been deployed.

Upper-Tier Defense. The core package relies on the Army's Theater High Altitude Area Defense to provide the overarching umbrella (or upper-tier) defense. As discussed in Chapter II, the upper tier acts as a first line of defense against medium- and long-range theater missiles. THAAD will provide moderate protection for an area a few hundred kilometers wide and will improve the effectiveness of the lower-tier defenses by reducing the number of incoming missiles that those systems will have to face. This system is intended to intercept missiles at far greater ranges and altitudes than the Patriot and therefore will have the chance for a second shot at some of the missiles that survive the first attempt at interception.

THAAD is based on land and would typically be deployed toward the rear of the theater to provide maximum protection to key targets and because it is a valuable asset. It will rely on a radar called the theater missile defense ground-based radar (TMD-GBR). Unlike Patriot and the Navy lower-tier defense, THAAD is an entirely new system. It requires developing a new interceptor missile, seeker, launcher, radar, fire-control system, and command and control software.

According to current plans, the Army will deploy THAAD and TMD-GBR beginning in 2001. However, the Ballistic Missile Defense Organization plans to have deployable prototypes of THAAD and its radar available for contingencies. These contingency systems should be available by the end of 1996, according to BMDO plans. Those deployment dates will depend on the parties to the Anti-Ballistic Missile Treaty reaching an agreement to permit THAAD.

CBO estimates that THAAD will cost $9.1 billion to complete, in addition to the $1.2 billion that the Congress has already appropriated through 1994. These funds will pay for completing development and purchasing 1,313 missiles and 14 batteries, each consisting of one command

center, one radar, and four to six launchers (see Table 5). Of that total, the TMD-GBR will cost $2.9 billion to complete, in addition to the $400 million already appropriated. According to BMDO, the annual cost to operate and support THAAD and its radar could exceed $200 million a year.

Battle Management System. The three core defenses will be tied together by a battle management and command, control, and communications system (BM/C^3). That system will coordinate the tiers and pass data to the TMD batteries from early-warning sensors such as the Defense Support Program satellites that were used to detect Iraqi Scud launches during the Persian Gulf War. The Ballistic Missile Defense Organization intends to spend $800 million to complete the BM/C^3 system, but to reduce costs, it plans to use existing BM/C^3 systems to the extent possible.

Active TMD Systems Outside the Core Program

In addition to the core systems, the Department of Defense is developing several other active TMD systems. Most are being funded by the Ballistic Missile Defense Organization, although the Air Force is funding two programs out of its own budget.

Advanced-Capability Theater Missile Defense Systems. The Ballistic Missile Defense Organization is developing three other theater missile defenses that they have labeled advanced-capability TMD systems: a sea-based upper-tier defense; a mobile Army point defense called Corps Surface-to-Air Missile (SAM); and an Air Force boost-phase interceptor.

Advanced technology development (developing prototypes and technologies) for all three will be funded at a modest level through 1999. Because of budget constraints, however, the Ballistic Missile Defense Organization expects to have enough money through 1999 to develop only one of those systems further. Starting in 1998, it will select one of the three--based on guidance from the Joint Chiefs of Staff--to enter the next stage of development, called the demonstration and validation phase. It plans to spend more than $400 million on the winning system from 1998 through 1999 for the demonstration and validation program. The Congressional Budget Office estimates that development and production would total $11 billion, excluding the $2.1 billion that CBO estimates will be spent on concept development for all three systems through 2010. For the two systems that are not chosen, the Ballistic Missile Defense Organization plans to start the demonstration and validation program sometime after 1999 as budget conditions permit.

It should be noted that the money that the Ballistic Missile Defense Organization has budgeted to develop and procure the winning system is based on Corps SAM, reportedly the most expensive of the three systems. If BMDO selects one of the other two, the extra money might be used to develop a second one of the three systems.

Sea-Based Upper Tier. The Navy's sea-based upper-tier defense (which it is calling the Sea-Based Wide Area Defense) would have a role similar to THAAD--namely, to provide an upper layer of protection. Unlike THAAD, though, much of the basic hardware for the system already exists. Rather than develop new radar, the Navy will upgrade the existing version of the Aegis radar on the roughly 50 cruisers and destroyers that will have the vertical launch system by the turn of the century and on nearly 80 of these ships by 2010.

For its interceptor missile, the Navy plans to pursue one of three options: deploy a version of THAAD, deploy a version of THAAD modified with an additional rocket booster to extend its range, or install a version of the Lightweight Exoatmospheric Projectile, or LEAP, on a Block IV Standard missile. All three missiles would fit into the existing vertical launch system on Aegis ships, which is longer than the THAAD launcher and therefore has room to extend the length (and consequently the range) of the interceptor. Like THAAD, the Navy's upper-tier system could not be fully tested or deployed unless it is determined to comply with the ABM treaty as a result of the ongoing negotiations between the United States, Russia, and the other parties to the treaty.

The biggest advantage of this sea-based system is that it would not need to rely on the availability of secure airfields to be transported to the theater. Thus, in some scenarios it could be employed more quickly than THAAD, provided that ships were nearby when the crisis erupted and that THAAD batteries had not been deployed in the region before the crisis. In addition, sea-based defenses would not require airlift, which would be in high demand during the early days of a conflict to transport other essential forces.

The Navy's area defense will be able to defend a larger area than the Army's THAAD system, primarily because the Aegis vertical launch system can accommodate longer missiles with greater range and higher speeds than the THAAD launcher. The effective range of the Navy and Army systems, however, will depend in part on the information available from external sensors such as Brilliant Eyes.

Range also depends critically on the nature of the enemy attack. In some situations, Navy area defenses may "waste" a portion of their coverage over the sea because the territory they are defending is between the ship and the attacker. For example, if the ship was deployed off the coast of Israel defending it against an attack from northwestern Iraq, only about half of the area that the ship could defend would be over Israel; the rest would be over the sea. The wasted coverage could be larger in some scenarios if antiship cruise missiles or mines forced the ship to remain well away from land. In contrast, a land-based system could be moved inland so that it could defend the area both in front of and behind the defense.

In other cases, however, ships might be deployed between the missile launcher and its target--for example, if the ships were located near the launcher and were defending Europe against missiles launched from North Africa or the Middle East, or defending Japan against missiles launched from North Korea. In those situations, ship-based systems might have a significantly greater effective range than a ground-based system that could not be placed to its best advantage.

The nature of the enemy attack influences the relative effectiveness of the Army and Navy systems in other ways. If the Navy adopts the LEAP/Standard missile option, its system could have a capability outside the atmosphere only, whereas the Army's THAAD system could also destroy targets within the upper atmosphere. As a result, although the Navy system might be able to intercept missiles farther away, it would have virtually no capability against missiles with ranges short enough (less than 350 kilometers) to fly within the atmosphere. Its capability would also be limited against those longer-range missiles that were intentionally flown on "depressed" trajectories that permitted them to remain within the atmosphere.

Corps SAM. The Army, with funding from the Ballistic Missile Defense Organization, is developing Corps SAM to deploy with its combat forces. Those forces are often left unprotected by the Patriot system, which is deployed to the rear of the theater to protect important fixed targets.

The Corps SAM system would replace Army and Marine Corps Hawk air-defense batteries. Although it will be designed primarily to provide defense against aircraft, the system will have the ability to provide defense against theater ballistic missiles with ranges less than 600 kilometers. But it will have very limited ability to provide defense against missiles with longer ranges. Because it will be deployed closer to troops near the front lines, Corps SAM will be better able than the PAC-3 to protect maneuver forces against the short-range ballistic missiles that are deployed by many countries

and that they are likely to face--such as Frog-7 and Scud-B missiles with ranges of 70 kilometers and 300 kilometers, respectively.

According to estimates of the Ballistic Missile Defense Organization, Corps SAM will cost $11.5 billion to complete development and production, including $500 million that CBO assumes that the missile agency will budget for concept development. That high cost primarily stems from the large number of missiles (2,404), launchers, and radars that the Army plans to deploy if this system is developed (see Table 5 on page 25).

Boost-Phase Interceptors. The idea behind boost-phase defense is appealing: intercept the missile while its rocket motor is still burning (and therefore easy to detect and destroy) and before it has a chance to release multiple warheads or decoys. The challenge, though, is to get the interceptors situated where they will be needed because the time or location that the enemy will choose to launch its mobile missiles is unknown. This concept was first explored in the context of defenses against long-range ballistic missiles; it culminated in a program of space-based interceptors called Brilliant Pebbles, which has since been canceled. The current plan against theater ballistic missiles is to place boost-phase interceptors on aircraft rather than in space.

Over the past few years, the Ballistic Missile Defense Organization and the Air Force have been exploring several concepts for boost-phase interception against theater ballistic missiles, including small interceptors based on unmanned aircraft (the so-called Raptor/Talon program), interceptors carried by aircraft, and a powerful laser carried by aircraft. The Raptor/Talon program has been phased out in favor of the manned approach. Indeed, the Administration's budget includes no money for Raptor/Talon beyond 1995.

The leading candidate for the first-generation boost-phase interceptor is a missile carried by manned air-superiority fighters or bombers. In one approach, fighters, loaded with one or two missiles each, would fly racetrack patterns near suspected missile launch areas. The fighters themselves would not be capable of detecting a missile; their radars are too limited. Instead, they would rely on a large aircraft similar to the Airborne Warning and Control System (AWACS) or the Joint Surveillance and Targeting Attack Radar System (JSTARS) that would carry a large X-band radar to detect and track the missile and tell the fighters where to point their weapons. This aircraft--which the Air Force is calling the multipurpose sensor and cueing platform--does not exist today and would require a new acquisition program.

As its name suggests, the multipurpose sensor and cueing platform will be used for more that just theater ballistic missile defense. It will also detect and track low-flying cruise missiles to improve the effectiveness of air defenses such as the Patriot and Corps SAM against this type of threat. According to the Air Force, no currently deployed airborne sensor can meet all of the requirements of the anti-cruise-missile mission.

The multipurpose sensor is still in the early stages of concept development. No official requirement has been established for the sensor, and no money has been budgeted for it. However, Air Force officials are beginning the process to establish both. Furthermore, the exact design of the system is in flux; it could involve procuring a new airborne system in addition to AWACS and JSTARS or adding new capabilities to one of those existing systems by upgrading hardware and software. These issues will be resolved as the boost-phase interceptor program progresses. Regardless of what form it takes, the current concept for the boost-phase interceptor assumes that this as yet unfunded sensor will be present. Thus, the costs of deploying effective boost-phase interceptors will be higher than the cost of developing the interceptors themselves.

Both the Air Force and the Ballistic Missile Defense Organization are funding the boost-phase interceptor. The budget will be slightly more than $100 million in 1995 and nearly $500 million through 1999. The Ballistic Missile Defense Organization has requested $61 million in 1995 and about $300 million through 1999 to develop and demonstrate a boost-phase interceptor. From its own budget, the Air Force will contribute the remainder, $52 million in 1995 and $200 million through 1999.

No estimate of total cost is available for the boost-phase interceptor; it is an entirely new program that is still in the early phase of its development. Nor are estimates available for the airborne multipurpose sensor and cueing platform. Although no reliable cost estimates exist, the boost-phase interceptor program, as currently envisioned, will require purchasing both the interceptor and the airborne radar. Each program is likely to cost several billion dollars.

The Air Force's Airborne Laser

In addition to the boost-phase interceptor program discussed above, the Air Force is also in the early stages of developing an airborne laser (ABL) to fulfill the boost-phase intercept mission, although it would be deployed later than the kinetic boost-phase interceptor. The Air Force is conducting a study

on possible concepts and designs for the airborne laser through 1997. They have requested about $60 million for the study: $2 million in 1994 and $20 million in each of the following years. The Air Force is funding the airborne laser by itself--money is included in the service's budget through 1997. If the study is successful and the Air Force decides to proceed with development, it will need an undisclosed amount of money from 1997 through 2010 in addition to what is included in its budget. CBO assumes that those costs would total $200 million beyond 1997, which is consistent with continuing a low level of effort on the program. However, this estimate could understate the costs significantly if the airborne laser becomes a major acquisition program.

PASSIVE DEFENSES AND ATTACK OPERATIONS

The second two pillars in the BMDO framework for theater missile defense are not commonly thought of as being part of theater missile defense. Yet they play an indispensable role in protecting U.S. forces and the populations of U.S. allies against ballistic missile attack.

Passive Defenses

Passive defenses are designed to address a wide range of threats, of which ballistic missiles are only a small portion. Those defenses can take two forms: operational and technical measures. Operational measures seek to minimize the effect that any one missile warhead can have. For example, forces can be dispersed so that only a small portion would be subjected to the effects of an attack. Troops can also use mobility and camouflage to reduce the chances of being detected and targeted. Finally, forces and civilians--particularly those in the rear areas of the theater where shelters are available--can take refuge from the effects of warheads carried by ballistic missiles as they did in Riyadh, Tel Aviv, and Jerusalem during the Persian Gulf War. They can also don protective clothing against chemical and biological weapons.

Technical measures attempt to mitigate the effects of ballistic missile warheads by applying technology. Examples include protective clothing, decontamination facilities, detection devices, antidotes, and vaccines.

Yet most of those passive defense efforts are focused on weapons of mass destruction and not ballistic missiles. A recent Department of Defense report identified more than $300 million that the United States currently devotes annually to developing and producing vaccines against biological

agents, $100 million for developing the capability to rapidly detect chemical and biological agents, and $5 million for protective clothing and decontamination facilities. But it did not identify any passive defense programs specific to ballistic missiles. Consequently, CBO has not included any funding for passive defenses in its estimates of the cost of the Administration's plan.

Attack Operations: Disrupting Missile Launch Operations

Attack operations--disrupting an adversary's ability to launch ballistic missiles during a war--can be an important method for limiting the damage an adversary can inflict on U.S. forces and the civilian populations of allies. Even if they are protected by active and passive defenses, fewer launched missiles mean a lower likelihood of leakage through what will always be an imperfect defense system. Attack operations try to disrupt launches by attacking missile and launcher manufacturing and storage facilities, transportation nodes through which they must travel, garrisons or hiding places near launch areas, launchers at launch sites either before or after they launch their missiles, and the command and control system through which the launcher receives its orders to launch.

One of the appeals of attack operations is that a gradual attrition of launchers over the period of a few weeks can have a significant effect on the number of missiles that an adversary can launch in a day. However, attacks need not destroy mobile missiles and related facilities to be effective; reducing the number of missiles that are launched by disrupting launch operations is also useful.

Attacking fixed sites like factories, transportation nodes, and garrisons is relatively straightforward, unless they are buried deep underground. However, launchers and missiles that are in inventory when the war begins are likely to be dispersed and hidden in temporary garrisons. The problem then becomes finding, tracking, and destroying those launchers and missiles.

Finding those mobile missile launchers is one of the most challenging aspects of theater missile defense. During the Persian Gulf War, U.S. air forces dedicated more than 1,200 aircraft flights (sorties)--or about 2 percent of the total sorties of ground attack aircraft during the war--to destroy mobile

Iraqi Scud missile launchers.[3] This includes 1,000 sorties where aircraft attacked other targets because they could not find any mobile missiles. Yet postwar analysis could not confirm that any Iraqi launchers had been destroyed by air power, despite what was ideal terrain for detecting the launchers.[4] Iraq's effective use of simple countermeasures (decoys and hidden shelters) further emphasizes what a daunting challenge hunting mobile missile launchers can be. Hunting missiles would be considerably more difficult in North Korea's mountainous regions, which are peppered with caves, or Bosnia's forested areas.

Coalition commanders considered Scuds to be an ineffective military weapon, but once the Iraqi attacks had begun, political pressure forced the commanders to devote resources to the Scud hunt that they wanted to use elsewhere.[5] Thus, even though a weapon has little direct military utility, it can cause armies to divert forces that they might otherwise use for military purposes.

Nonetheless, the attack operations against Scuds were not fruitless. At the very least, the operation forced the Iraqis to launch missiles hurriedly, which decreased the accuracy of the missile strikes. Anti-Scud operations also forced the Iraqis to launch their missiles mostly at night, when it was more difficult for U.S. fighters to find the launchers. Furthermore, data suggest that coalition air power reduced the Iraqis' ability to launch missiles. During the first week of the war, Iraq launched an average of 5 missiles per day and a maximum of 14 in one day. This rate dropped to an average of 2.5 missile launches per day during the second week and 1.5 per day during the third and fourth weeks, possibly because of attack operations. But during the fifth and last week, Iraqi forces may have adapted somewhat because they were able to increase the average number of missiles launched to roughly two per day, although this was short of early war highs.

Data also suggest that attack operations may have had a similar impact on Iraq's ability to launch several missiles simultaneously, which can significantly affect the success of active ballistic missile defenses. During the first two weeks, Iraq launched as many as six within a three-minute period. During the second two weeks, the Iraqis never managed to launch salvos of

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3. For a detailed discussion of the anti-Scud campaign, see Thomas Keaney and Eliot Cohen, *Gulf War Air Power Survey Summary Report* (Department of the Air Force, 1993), pp. 83-88 and p. 184; and Eliot Cohen, *Gulf War Air Power Survey*, vol. 2 (Department of the Air Force, 1993), part 1, pp. 171-191, and part 2, pp. 131-132 and 330-340.

4. Cohen, *Gulf War Air Power Survey*, part 2, p. 330.

5. Ibid., pp. 182-185.

more than one missile within a three-minute period. During the third and final two-week period of the war, Iraq recovered somewhat and launched salvos similar in size to the early weeks of the war.

Mindful of its experience in the Persian Gulf War, the Department of Defense is working to improve its ability to detect, track, and destroy mobile missile launchers. The Pentagon's Advanced Research Projects Agency is funding a program called Warbreaker to address U.S. shortcomings against "time-critical" targets, of which ballistic missile launchers are perhaps the most prominent. Through a variety of projects, Warbreaker is attempting to improve the ability of U.S. forces by developing new sensors and detection methods that might be deployed toward the end of the next decade. DoD plans to spend $100 million on Warbreaker in 1995, and about $140 million per year thereafter. Any new systems that emerge from this effort will have to be funded by the services.

The Air Force is also working to improve its ability to perform attack operations. It has conducted several exercises that use existing sensor and command and control systems in new ways to detect and track mobile missile launchers. It is also exploring modest upgrades to existing systems. To continue those efforts, it plans to spend roughly $30 million annually through 1999. The Alert, Locate, and Report Missiles (ALARM) system (see below) and Brilliant Eyes sensors will also help during attack operations because they can better pinpoint a ballistic missile's launch location.

Other than the efforts of the Advanced Research Project Agency and Air Force, several small efforts within the Air Force and the other services will improve in some way the ability of the United States to conduct attack operations. Like the Air Force, the Navy is developing tactics for using its new precision-guided munitions to attack mobile targets. The Army is studying how best to use existing and soon-to-be-delivered systems to attack mobile targets up to 300 kilometers deep in enemy territory.[6] Some of the systems being considered are the extended-range missiles for the Army Tactical Missile System (ATACMS), Brilliant Anti-Tank (BAT) submunitions, improved BAT submunitions, Apache attack helicopters with Longbow sensors, and short-range unmanned air vehicles (UAVs). The Army is also working to reduce the time between when the target is detected and when it is attacked. Because none of the Army or Navy efforts is intended primarily to attack mobile missiles, identifying the funds associated with attack

6. For a helpful discussion of the Army's attack operations efforts, see Lieutenant Colonel John Gordon, "Theater Missile Defense: An Army Perspective," *U.S. Naval Institute Proceedings* (forthcoming).

operations is difficult. Consequently, CBO did not include any Army or Navy funding in its estimate of attack operation costs.

THEATER MISSILE DEFENSE-RELATED SPACE-BASED SENSORS

The Department of Defense is developing two space-based sensors, both related to theater missile defenses. The Air Force is building an improved early-warning satellite. At the same time, the Ballistic Missile Defense Organization is working on a sophisticated satellite-based sensor called Brilliant Eyes that is designed to provide very good tracking data to ground-based defenses. (The Ballistic Missile Defense Organization is starting to use the name Space and Missile Tracking System for this system.) Because detecting and tracking theater ballistic missiles is one of the primary missions of these sensors and because they will play an important role in planned theater missile defense architectures and attack operations, they are included here.

ALARM Early-Warning Satellite. The Air Force is proposing to develop a system of early-warning satellites to replace its existing Defense Support Program satellites. DSP satellites were intended to detect launches of Soviet intercontinental ballistic missiles and submarine-launched ballistic missiles and provide an early estimate of the size and composition of the attack as well as the general areas likely to be targeted. It was not intended to support theater missile defense or counterforce operations against missile launchers, although it performed fairly well during the Persian Gulf War.

Nevertheless, the war demonstrated that DSP satellites do not have the ideal sensor for detecting theater ballistic missiles. Because each satellite has a wide field of view and views the same spot on the earth every 10 seconds, it does not provide tracking data that are precise enough to pinpoint the launch location. Nor does it allow command authorities to estimate precisely the missile's intended target. Finally, DSP is unable to reliably detect and track shorter-range ballistic missiles such as Scud-Bs that have ranges of 300 kilometers or less.

To address those shortcomings, the Air Force proposed a new early-warning satellite called the Follow-on Early Warning System (FEWS). However, budget pressures have forced the service to scale back the program somewhat. The new system, called ALARM, would have a sensor that is similar to FEWS but have less processing capability onboard the satellite. The first ALARM satellite will be delivered in 2004. ALARM is supposed to cost less in the short run than FEWS but will ultimately cost almost the

same because the Air Force plans to upgrade it to a configuration almost as capable as FEWS. Upgrades will begin with the fifth ALARM satellite, which will be delivered in 2008.

According to Air Force officials, ALARM will be able to observe a missile much more frequently during its boost phase than the Defense Support Program. In its original configuration, it will be able to focus on any two places on the globe with higher sensitivity than the DSP satellites. That will make ALARM better able to detect short-range theater missiles such as Scud-Bs and provide more precise estimates of launch and impact points. Such data will help terminal defenses, such as Patriot and THAAD, focus their radar on a smaller portion of sky. Doing so will extend the range of their radar and as a result increase the size of the area that they can defend. ALARM will also help other sensor systems locate and track the empty mobile launchers so that they can be destroyed. The Air Force plans to purchase its first block of four satellites in this original configuration.

As a result of an upgrade program (called a preplanned product improvement, or P^3I, in Pentagon parlance), the second and third blocks of ALARM satellites will be able to provide this detection capability for theater ballistic missiles worldwide, and not just in two places. They will probably also have onboard processing that will allow warnings to be sent directly to commanders in the theater.

The Department of Defense plans to spend $12.1 billion to develop ALARM and produce 12 satellites through 2018 (see Table 5 on page 25). CBO estimates that about $2 billion of that amount will fund the development necessary to add most of the advanced features like onboard processing and laser crosslinks to the last eight of those satellites.

Brilliant Eyes. To track theater ballistic missiles more accurately than is possible with early-warning satellites and to help distinguish targets from decoys, the Ballistic Missile Defense Organization is developing a system of space-based sensors called Brilliant Eyes. Brilliant Eyes will accomplish this task by tracking missiles and their warheads after the missile completes its boost phase (that is, when its rocket motor stops burning). Early-warning systems like DSP and ALARM do not have this capability to track missiles during midcourse. Originally an important component of the national missile defense planned by the Bush Administration, Brilliant Eyes is now being touted for its ability to enhance theater as well as national missile defenses.

Each Brilliant Eye is a satellite equipped with three types of infrared sensors. The first is a wide field-of-view, short-wave infrared sensor that will

stare down at the earth to detect missiles shortly after they have been launched, much as DSP does. This is known as the acquisition sensor because its task is to find (acquire) the target. The second and third are medium- and long-wave infrared sensors with very narrow fields of view that will be able to see cool missile warheads against the cold background of space. These sensors track the targets. Because the narrow field-of-view sensors see such a small part of the sky (it is like looking through a soda straw), the wide field-of-view sensor must tell them where to look. The satellites will be deployed so that at least two will be able to observe any missile launch with their wide and narrow field-of-view sensors. If they are looking in the correct place when the missile is launched, they will be able to see the missile with their downward-looking acquisition sensor; otherwise, they will be directed where to look by early-warning sensors such as DSP or ALARM.

The tracking information (also called cueing data) from Brilliant Eyes would expand the area that these terminal defenses will be able to defend--especially area defenses like THAAD and the Navy upper-tier system--by cueing their radar to the proper location. This would increase the range at which the radar could see the incoming missiles because it would allow the radar to concentrate its energy on a smaller portion of the sky.

Cueing data should also allow the area defenses to launch their interceptors while the target is still outside of the radar's range. Such a capability would significantly expand the area that an upper-tier defense such as THAAD or the Navy upper-tier system could defend against medium- to long-range theater ballistic missiles. For example, according to simulations done by CBO, the size of a footprint for a notional area defense like THAAD would almost double--from 240,000 square kilometers to 400,000 square kilometers against a 600 kilometer missile like the Al Hussein.[7] That is why Brilliant Eyes is the non-TMD system that the Ballistic Missile Defense Organization plans to develop most extensively before 2000. Indeed, BMDO considers the system important enough to devote $150 million to $200 million to it annually, money that could be used instead to develop one or more of the three advanced-capability TMD systems--Corps SAM, Navy upper-tier, and boost-phase interceptors. It plans to launch two prototype satellites in 1998. Those prototypes will not be equipped with long-wave infrared sensors,

7. Like all footprints discussed in this paper, these footprints are for illustrative purposes only. They show only that the interceptor could fly out to the appropriate point in space to intercept the missile and do not imply that the interception would be successful. Because these footprints exclude many factors, they most likely overstate somewhat the area that the system can defend. Nevertheless, they are still useful for showing the effects of adding midcourse sensors like Brilliant Eyes. These footprints are derived from a model given to the Congressional Budget Office by the Ballistic Missile Defense Organization. CBO uses its own assumptions in calculating these notional footprints.

one of the most technically challenging aspects of the program, but one not required for tracking theater ballistic missiles.

The cueing data from Brilliant Eyes will be good enough that, in theory, missile intercepts can occur entirely beyond the range of the theater missile defense radar. Such a capability would greatly expand the area that an upper-tier defense like THAAD could defend against medium- to long-range theater ballistic missiles. The way that THAAD and the Navy's Aegis/Standard missile system are designed, however, they will not be able to take advantage of this capability. That is, they will not be able to guide their interceptors to their targets based only on data from Brilliant Eyes. The reason for this limitation is that data from the satellites must be communicated to the interceptors while they are in flight. As currently envisioned, THAAD and the Navy upper-tier system will use their radar to communicate with the interceptors. As a result, an interceptor cannot receive course corrections once it is much beyond the range of the radar. For Brilliant Eyes to guide the interceptor to its target, it would have to communicate directly with the interceptor or use some type of ground- or air-based relay. Neither Brilliant Eyes, THAAD, nor the Navy upper tier has been designed with this capability, according to BMDO, although future theater missile defense systems may be able to take advantage of the full capabilities of Brilliant Eyes.

The first of the planned 28 production satellites will be deployed starting in 2004. The satellites will be relatively lightweight; at 1,300 pounds each, the Ballistic Missile Defense Organization plans to launch four on a single Delta II medium-lift rocket. BMDO will deploy the satellites in relatively low-altitude orbits so that the satellites can view missiles against the cold background of space. If 12 were deployed in so-called low-inclination orbits that stay within roughly 30 degrees of the equator, they could provide a significant capability for theater missile defense because they would cover the areas of the globe where threats from ballistic missile attack are highest, such as the Middle East and Korea. However, to provide coverage of most of the globe (including Russian and Chinese missile fields and the northern trajectories those missiles would fly toward the United States), the Air Force would have to deploy additional satellites, especially in more inclined (northerly) orbits.

The Ballistic Missile Defense Organization estimates that this program will cost $3.3 billion to complete. The total cost for the program is $3.8 billion if money appropriated through 1994 is included. According to BMDO, the annual cost to operate and support the Brilliant Eyes constellation will be $200 million once the constellation has been fully deployed. This includes the

cost to launch new satellites each year to replace aging ones (two to three per year if one assumes a service life of 10 years).

THE COSTS OF THE ADMINISTRATION'S PLAN

The Administration will spend some $2.7 billion on theater missile defense in 1995. The lion's share of this funding can be found within the budget of the Ballistic Missile Defense Organization. But other efforts are under way within the services to support some of the programs funded primarily by BMDO. In addition, the Air Force funds research on attack operations and sensor programs that are not part of BMDO. The Advanced Research Projects Agency also conducts research on attack operations. Together, these efforts make up the Administration's budget for developing theater missile defenses. The costs presented in this section are for research, development, and procurement; they exclude the costs of operating the systems once they have been deployed.

The Budget for the Ballistic Missile Defense Organization

The budget of the Ballistic Missile Defense Organization is the primary source of funds for theater missile defense. The Clinton Administration has taken significant steps to reduce the size of that budget in both the long and short run. The brunt of these cuts has been borne by the National Missile Defense program, which has been reduced from a major acquisition program to a "technology readiness program" whose goal is to develop technologies so that they will be available if the nation decides to develop such a defense. Funding for theater missile defense has been reduced somewhat, and it has become BMDO's primary focus.

Near-Term Costs. The Administration has presented a plan for BMDO that will cost roughly $17 billion from 1995 through 1999. This amount represents a sharp reduction from the plan the Administration inherited from the Bush Administration, which called for spending roughly $37 billion over the same period. The $20 billion savings comes primarily from the steep reductions in the restructured National Missile Defense program.

Of that $17 billion, the Ballistic Missile Defense Organization has identified nearly $11 billion for theater missile defense (see Table 6). About 70 percent of the theater missile defense budget (roughly $8 billion) will be spent developing and purchasing the core TMD package. Specifically, upgrades of the Patriot PAC-3 system will cost $2.5 billion over the next five

years, THAAD will cost $3.5 billion (including $1 billion for its ground-based radar), the Navy lower-tier defense will cost $1.3 billion, and BM/$C^3$ will cost $300 million (see Table 7). The Ballistic Missile Defense Organization will also pay some $60 million to upgrade the antiballistic missile capability of the Marine Corps' Hawk air-defense system. Because of its low cost and because none of the options in Chapter V will affect it, the Hawk upgrade is not discussed elsewhere in this paper.

The remaining 30 percent of the money identified for theater missile defense in the BMDO budget will fund technology development for the advanced-capability TMD systems (Corps SAM and sea-based upper-tier defenses), international programs including the Israeli Arrow interceptor, technical support, and management.

TABLE 6. THE ADMINISTRATION'S BUDGET REQUEST FOR THE BALLISTIC MISSILE DEFENSE ORGANIZATION (By fiscal year, in billions of 1995 dollars)

						Total		
Category	1995	1996	1997	1998	1999	1995 to 1999	1999 to 2010	1995 to 2010
			Theater Missile Defense[a]					
Core Systems	1.5	1.6	1.4	1.5	1.7	7.7	9.0	16.7
Advanced-Capability TMD Systems	0.1	0.1	0.1	0.3	0.4	1.0	11.7	12.8
TMD Research and Support	0.4	0.4	0.4	0.4	0.4	2.0	3.4	5.4
International Systems	0.1	b	b	b	0.0	0.2	0.4	0.6
Subtotal	2.1	2.2	2.0	2.3	2.5	10.9	24.5	35.5
			National Missile Defense and Other Efforts					
National Missile Defense, Research, and Support	1.0	1.0	0.9	0.9	0.9	4.8	8.2	13.0
Brilliant Eyes Satellite	0.1	0.1	0.1	0.2	0.2	0.8	2.5	3.3
Subtotal	1.2	1.1	1.1	1.1	1.1	5.5	10.7	16.3
			Total Ballistic Missile Defense Organization Budget					
Total	3.3	3.3	3.1	3.4	3.5	16.6	35.3	51.8

SOURCE: Congressional Budget Office based on information from the Department of Defense.

NOTE: TMD = theater missile defense.

a. Includes boost-phase interceptor funds of $1.1 billion through 2010.

b. Less than $50 million.

TABLE 7. CBO'S ESTIMATE OF THE ADMINISTRATION'S BUDGET REQUEST FOR THEATER MISSILE DEFENSE AND SPACE-BASED SENSORS (By fiscal year, in billions of 1995 dollars)

Category	1995	1996	1997	1998	1999	Total 1995 to 1999	Total 1999 to 2010	Total 1995 to 2010
				BMDO's Theater Missile Defense Activities				
Core Systems								
PAC-3	0.6	0.7	0.5	0.5	0.4	2.5	0.4	3.0
THAAD/GBR	0.7	0.6	0.6	0.7	1.0	3.5	5.6	9.1
Navy lower-tier	0.2	0.3	0.3	0.3	0.2	1.3	2.6	3.9
Battle management	a	a	0.1	0.1	a	0.3	0.4	0.7
Subtotal	1.5	1.6	1.4	1.5	1.7	7.7	9.0	16.7
Advanced-Capability TMD Systems								
Corps SAM	a	a	a	a	a	0.1	0.3	0.5
Navy upper-tier	a	a	a	a	a	0.1	0.3	0.5
Boost-phase interceptor	0.1	0.1	0.1	0.1	0.1	0.3	0.7	1.1
Dem/Val Program	0.0	0.0	0.0	0.2	0.2	0.4	10.3	10.7[b]
Subtotal	0.1	0.1	0.1	0.3	0.4	1.0	11.7	12.8
TMD Research and Support	0.4	0.4	0.4	0.4	0.4	2.0	3.4	5.4
International Programs	0.1	a	a	a	a	0.2	0.4	0.6
Total	2.1	2.2	2.0	2.3	2.5	10.9	24.5	35.5
				Other Theater Missile Defense Activities				
Air Force TMD								
Airborne laser	a	a	a	a	a	0.2	0.2	0.4
Attack operations	a	a	a	a	a	0.1	0.3	0.4
Boost-phase interceptor	0.1	0.1	0.1	a	a	0.2	0.2	0.4
Army Patriot Upgrades	0.1	a	a	a	a	0.2	0.0	0.2
Warbreaker Program	0.1	0.1	0.1	0.1	0.1	0.7	1.2	1.8
Total	0.3	0.3	0.3	0.2	0.2	1.3	1.8	3.1
				TMD-Related Space-Based Sensors				
ALARM	0.2	0.2	0.1	0.3	0.5	1.2	6.9	8.1[b]
Brilliant Eyes	0.1	0.1	0.1	0.2	0.2	0.8	2.5	3.3
				Total Theater Missile Defense and Space-Based Sensors				
All Programs	2.7	2.8	2.6	2.9	3.4	14.3	35.7	50.0

SOURCE: Congressional Budget Office based on information from the Department of Defense.

NOTES: Costs exclude those to operate a system after it has been deployed. BMDO = Ballistic Missile Defense Organization; PAC = Patriot Advanced Capability; THAAD = Theater High Altitude Area Defense; GBR = Ground-Based Radar; TMD = Theater Missile Defense; SAM = Surface-to-Air Missile; Dem/Val = Demonstration and Validation; ALARM = Alert, Locate, and Report Missiles.

a. Less than $50 million.

b. Total costs for advanced-capability TMD and ALARM are higher than these figures because the programs continue beyond 2010.

The Ballistic Missile Defense Organization plans to devote roughly $6 billion to general "ballistic missile defense" through 1999 (see the second panel of Table 6). This category includes costs of about $3 billion to develop technologies specific to national missile defense such as sensors, radar, and interceptor kill vehicles, as well as technologies that could be useful for either national or theater defenses. That account also includes costs of about $2 billion for relevant management and support activities as well as the salaries for all Ballistic Missile Defense Organization employees. The cost of developing Brilliant Eyes (about $1 billion through 1999) is included in the budget request for the "ballistic missile defense" account.

Theater Missile Defense Funding from the Service's Budgets

The Air Force has budgeted nearly $100 million in 1995 and almost $400 million through 1999 for three theater missile defense programs. First, it plans to spend $52 million in 1995 and some $200 million over the next five years on a program to develop a boost-phase interceptor (see Table 8). Second, it has requested $20 million to fund development of an airborne laser that could also intercept missiles during the boost phase. The service has budgeted $20 million annually through 1997; CBO assumes that it will continue this effort beyond 1997. Third, the Air Force plans to spend the $27 million in 1995 and more than $100 million over the next five years to explore short-term improvements to its existing hardware and operational doctrine that will enhance its ability to detect, track, and destroy missile launchers on the ground.

The Army plans to spend $200 million of its own funds to upgrade several elements of the Patriot system through 1999, including improvements to the command center and launchers. The Navy has no money specifically budgeted for active defenses, and neither the Army nor the Navy has budgeted money for attack operations.

Total Costs of the Theater Missile Defense Program

Adding all of the components outlined above gives the total resources devoted to developing and purchasing theater missile defenses. CBO estimates that, in 1995, the Administration plans to spend $2.7 billion on theater missile defense efforts and related space-based sensors. About $2.2 billion, or 83 percent, would come from the BMDO budget, 9 percent would come from the Air Force, 2 percent from the Army, and 5 percent from the Advanced Research Projects Agency (see Table 8). Through 1999, these proportions

stay roughly the same, although Army spending would decrease and Air Force budgets increase somewhat. DoD plans to spend more than $14 billion on theater missile defense and related sensors, of which nearly $12 billion will come from the Ballistic Missile Defense Organization.

As Table 9 illustrates, in 1995, $2.2 billion (about 84 percent of the total amount requested for theater missile defense) will be spent on developing and procuring active missile defenses and related battle management systems, $300 million (10 percent) on developing space-based sensors, and about $200 million (6 percent) on improving the ability of U.S. forces to conduct attack

TABLE 8. THE ADMINISTRATION'S BUDGET REQUEST FOR TMD AND RELATED SPACE-BASED SENSORS, BY AGENCY (In billions of 1995 dollars)

						Total		
Category	1995	1996	1997	1998	1999	1995 to 1999	1999 to 2010	1995 to 2010
BMDO								
Core systems	1.5	1.6	1.4	1.5	1.7	7.7	9.0	16.7
Advanced-capability TMD	0.1	0.1	0.1	0.3	0.4	1.0	11.7	12.8
Brilliant Eyes	0.1	0.1	0.1	0.2	0.2	0.8	2.5	3.3
Other TMD	0.5	0.4	0.4	0.4	0.4	2.2	3.8	6.0
Subtotal	2.2	2.3	2.1	2.4	2.6	11.7	27.1	38.8
Air Force								
Boost-phase interceptor	0.1	0.1	0.1	a	a	0.2	0.2	0.4
Airborne laser	a	a	a	a	a	0.1	0.2	0.3
Attack operations	a	a	a	a	a	0.1	0.3	0.4
ALARM	0.2	0.2	0.1	0.3	0.5	1.2	6.9	8.1
Subtotal	0.2	0.3	0.2	0.3	0.6	1.7	7.5	9.2
Army Patriot Upgrades	0.1	a	a	a	a	0.2	a	0.2
ARPA Warbreaker	0.1	0.1	0.1	0.1	0.1	0.7	1.2	1.8
Total	2.7	2.8	2.6	2.9	3.4	14.3	35.7	50.0

SOURCE: Congressional Budget Office based on information from the Ballistic Missile Defense Organization, the Air Force, and the Department of Defense.

NOTES: Costs exclude those to operate a system after it has been deployed. TMD = theater missile defense; BMDO = Ballistic Missile Defense Organization; ALARM = Alert, Locate, and Report Missiles; ARPA = Advanced Research Projects Agency.

a. Less than $50 million.

operations. Through 1999, the proportions stay about the same. The Administration plans to spend 80 percent ($11.4 billion) on active defenses, 14 percent ($2.0 billion) on space-based sensors, and 6 percent ($800 million) on attack operations.

Long-Term Costs for Theater Missile Defense

Because most of the systems that the Ballistic Missile Defense Organization and other agencies are developing will not be deployed by 1999, short-term costs do not reflect the real cost of the Administration's plan for theater missile defense. Although accurately estimating long-term costs is difficult, the Congress needs to have a rough sense of the implications of current policies and their alternatives.

Based on detailed data about system acquisition costs provided by the Ballistic Missile Defense Organization, CBO estimates that the Administration's plan for theater missile defense including space-based sensors will cost nearly $50 billion through 2010, of which $39 billion will be spent by the Ballistic Missile Defense Organization (see Table 8). About 73 percent of the money will be spent on active missile defenses, about 23 percent on TMD-related space-based sensors, and the remaining 4 percent on attack operations. Of course, these sums exclude the cost to operate the systems once they have been deployed, which could total more than $400 million annually by 2010.

TABLE 9. COSTS OF THEATER MISSILE DEFENSE, BY FUNCTION
(In billions of 1995 dollars)

Category	1995	1996	1997	1998	1999	Total 1995 to 1999	Total 1999 to 2010	Total 1995 to 2010
Active Defenses and Battle Management	2.2	2.3	2.1	2.3	2.5	11.4	24.9	36.3
Attack Operations	0.2	0.2	0.2	0.2	0.2	0.8	1.4	2.2
TMD-Related Space-Based Sensors	0.3	0.3	0.3	0.4	0.7	2.0	9.4	11.4
Total	2.7	2.8	2.6	2.9	3.4	14.3	35.7	50.0

SOURCE: Congressional Budget Office based on data from the Department of Defense.
NOTES: Costs exclude those to operate a system after it has been deployed. TMD = theater missile defense.

The basic assumption underlying this estimate is that all the systems that BMDO plans to develop will be developed and procured according to the BMDO schedule. In other words, only the core systems, ALARM, Brilliant Eyes, and one of the advanced-capability TMD systems will have at least some units deployed by 2010.

CBO also assumes that the funding for attack operations within the Air Force and the Advanced Research Projects Agency will continue at 1999 levels through 2010. Those efforts could possibly be reduced, but given the importance that DoD is placing on hunting mobile missiles, funding is more likely to increase.

CBO's approach entails obvious uncertainties. For example, programs could be canceled or added. Systems could experience cost growth, a phenomenon that is common in developing state-of-the-art weapons. Also, the long-term cost estimates do not include systems that are so early in their development that no cost estimates are available. The airborne radar that the Air Force will require for its boost-phase interceptor is an example of such a system. Another example is the airborne laser that the Air Force hopes to continue beyond 1997, although it has not yet budgeted money for it.

Another shortcoming is that these estimates do not take into account the dynamic relationship between offense and defense. That is, they account only for the expense of buying the current generation of hardware and not the modifications or upgrades that are required to overcome the countermeasures that a rational adversary would employ to penetrate U.S. theater missile defenses. Modifications and upgrades are commonly made on many weapon systems, so it is reasonable to assume that they would occur with theater missile defenses. The cost associated with this cycle of action and reaction for defenses against strategic missiles was one of the central reasons that the Soviet Union and the United States created the Anti-Ballistic Missile Treaty, and to date, no one has demonstrated that a similar phenomenon would not occur in the realm of theater defenses.

CHAPTER IV

THEATER MISSILE DEFENSE AND THE ABM TREATY

The Anti-Ballistic Missile Treaty sharply limits the ability of the United States and Russia to defend their territories against ballistic missiles with intercontinental ranges, so-called strategic missiles. The treaty does not limit theater ballistic missile defenses, but it has provisions that prohibit giving them capabilities to counter strategic ballistic missiles or testing them "in an ABM mode." However, the treaty does not define what constitutes a strategic ballistic missile.

The Administration's plan for theater missile defense raises several important issues with the ABM treaty. Primary among them is the dividing line between theater and strategic missile defenses. Space-based sensors raise a second issue: at what point might they become substitutes for an ABM radar, a key element that is strictly limited by the treaty to guard against breakout? The United States will have to resolve the issues with Russia and to the satisfaction of the Congress before any controversial systems can be tested and deployed.

THE DISTINCTION BETWEEN THEATER AND STRATEGIC MISSILE DEFENSES

Although the ABM treaty limits strategic defenses, it does not define the difference between strategic and theater missiles. Historically, the United States has addressed this issue by using a threshold to trigger the treaty compliance review process for its own systems. Known as the Foster Box, after the Director of Pentagon Defense, Research, and Engineering, John Foster, who spoke of it during Senate ratification hearings for the ABM treaty, it defines the threshold to be a maximum target speed of 2 kilometers per second (corresponding to a missile with a maximum range of roughly 500 kilometers) and a maximum altitude of 40 kilometers. Although it was never officially presented to the Soviet Union, the Foster Box provided guidance within the Department of Defense about when a system that was being developed should be reviewed for its compliance with the ABM treaty. Systems below the threshold have virtually no ABM capability and are therefore not reviewed; systems above the threshold are subject to scrutiny by an internal compliance review board.

Nevertheless, because Foster's statement was part of the public record on the ratification hearings, some in the Senate believe that it represents a "shared interpretation" between the Senate and the executive branch on the definition of an ABM system. The current Administration disagrees with that view. The Foster Box has also become an important demarcation for supporters of the ABM treaty outside the Senate.

The reason for adopting such a low threshold was that a few of the submarine-launched ballistic missiles considered to be strategic under the 1972 Strategic Arms Limitation Talks (SALT I) Treaty had ranges of 1,400 kilometers--short by today's standards and well within the realm of what is now considered to be a theater ballistic missile. In addition, the purpose of the threshold was to distinguish ABMs from defenses against aircraft, which both sides had deployed. At the time that the treaty was completed, neither side had developed theater ballistic missile defenses.

Also important for ensuring that theater missile defenses could not be "upgraded" to ABM systems is the provision contained in Article VI that forbids deploying any system that has the capability (whether demonstrated by testing or not) to provide defense against strategic ballistic missiles.

Today, the world has changed substantially. All of the strategic missiles now expected to be deployed by Russia and the United States under the recent Strategic Arms Reduction Talks treaties (START I and START II) have ranges in excess of 6,000 kilometers (although France, the United Kingdom, and China all deploy nuclear ballistic missiles with ranges shorter than 6,000 kilometers). At the same time, the range of theater ballistic missiles available in the developing world has increased (see Chapter II). The Al Hussein modification of the Scud missile that Iraq used during the Persian Gulf War had a range of 600 kilometers. North Korea has reportedly developed and tested a further modification of the Scud, called the No Dong, that may be able to travel 1,000 kilometers. And Saudi Arabia has purchased CSS-2 missiles with 2,700 kilometer ranges from China. In addition, recent public statements by the Central Intelligence Agency have indicated that North Korea is in the early stages of developing two missiles--dubbed Taepo Dong--with ranges greater than 1,000 kilometers. According to one report, these ranges might be as long as 2,000 to 3,500 kilometers.

Given this trend toward longer-range missiles, the new focus of the United States on regional conflict, and the growing number of theater ballistic missiles deployed by Russia's neighbors, it is not surprising that the Administration, many Members of Congress, and even Russia support clarifying the distinction between theater and strategic ballistic missiles.

But how permissive should this new dividing line be? If an ABM system could be deployed surreptitiously, it could cause instability in the strategic nuclear balance between Russia and the United States or make them reluctant to negotiate further cuts in nuclear forces. Thus, many experts who support the treaty believe that any changes should still provide a substantial "firebreak" between theater missile defenses and ABM systems. In other words, any formalized distinction between theater and strategic defenses should provide insurance that a theater missile defense system cannot easily be upgraded into an ABM system. What provides an adequate firebreak is currently the subject of a vigorous debate.

THE ADMINISTRATION'S DEMARCATION PROPOSAL

This past November, the Administration made a proposal to Russia that would establish a formal demarcation between strategic and theater ballistic missiles. According to published reports, the Administration framed its request by stating that the United States understood the theater threat to be ballistic missiles with ranges of roughly 3,000 kilometers and that it was seeking an agreement with Russia that systems designed to counter that threat would be permitted under the ABM treaty as theater ballistic missile systems. To that end, it proposed that:

- A strategic missile defense be defined as any defense that had been tested against a target with a maximum speed greater than 5 kilometers per second.

- Article VI of the ABM treaty be altered or clarified so that only those systems demonstrated to have ABM capability would violate the treaty. Under the current version of the treaty, any system with the capability to intercept strategic missiles is limited by the treaty, whether that system has been tested or not.

- No other sections of the treaty would be altered.

This proposal would allow the United States to deploy the Theater High Altitude Area Defense, the sea-based upper-tier defense, and boost-phase interceptors as long as they are not tested above the 5-kilometer threshold.

The Russian delegation has not accepted the proposal, but neither has it rejected it outright, according to published reports. In fact, the Russians reportedly suggested that the definition of theater ballistic missiles include those with ranges as long as 3,500 kilometers--a proposal that the United

States is reported to have accepted. Since December 1993, Russia has made several counterproposals seeking to limit further the capability of theater missile defenses. Among them are proposals to limit the speed of theater missile defense interceptors (not targets) to 3 kilometers per second--which would allow the Theater High Altitude Area Defense but probably forbid boost-phase interceptors and the Navy's area defense--and restrict the locations where these systems could be deployed. At publication time, this issue had not been resolved, and negotiations were continuing.

The Administration argues that the changes in the treaty may be minor enough that they can be accomplished without a formal agreement requiring Senate advice and consent. However, the Administration plans to await the final outcome of negotiations and to consult closely with the Congress before making a decision. Nevertheless, some Senators are convinced that the magnitude of the Administration's proposed changes will require Senate approval.

Response to the Administration's Proposal

Within the United States, the Administration's proposal was met with protest from some ABM treaty supporters and praise from supporters of theater ballistic missile defenses. Champions of national missile defenses have expressed concern about the Administration's retreat from the negotiating position of the Bush Administration that would have allowed a more extensive ABM system than currently allowed by the treaty. Because Russia has not accepted the Administration's proposal, the debate continues.

Critics charge that, although clarifying the demarkation between strategic and ballistic missile defenses is necessary, the Administration's proposed threshold is too high and does not leave a large enough firebreak between theater and strategic ballistic missile defenses. An effective defense against missiles traveling at 5 kilometers per second still has substantial capability against missiles with speeds of 7 kilometers per second, they argue. More important, the Administration's original proposal would restrict only one parameter of theater missile defenses--the target speed against which the system is tested--and, therefore, would allow Russia or the United States to deploy advanced theater missile defense systems that had been designed to have significant ABM capabilities. A party to the treaty could quickly exceed the treaty limits; a few successful tests against strategic missiles could demonstrate that the system worked.

The effects of the Administration's proposed changes to the ABM treaty could be most significant with the upper-tier system proposed by the Navy. Some Navy officials have suggested that Aegis ships deployed along the coast of the United States could--depending on the assumptions made--protect large portions of the country against a limited attack by Russia, especially if supplemented by Brilliant Eyes space-based sensors (discussed below) and a treaty-compliant ABM system deployed at Grand Forks, North Dakota.

In addition, critics challenge the Administration's assertion that missiles with ranges of roughly 3,000 kilometers define the threat. After all, the longest-range missile that has been deployed in the developing world is the 2,700 kilometer CSS-2 that Saudi Arabia bought from China in 1986. These missiles are conventionally armed, and the Saudis are allies of the United States. Furthermore, China has not sold any more of these missiles abroad, and there is significant pressure on the Chinese not to make any further sales. The next most capable missile in the developing world is the North Korean No Dong, which reportedly has a range of 1,000 kilometers, far less than the CSS-2. The missile is still in development and has never been tested over its full range.

Critics also worry that the clarification of Article VI proposed by the Administration will allow strategic defenses masquerading as theater missile defenses to be deployed without being subject to the limits that the ABM treaty places on numbers, locations, and mobility as long as they have not been tested against targets traveling faster than 5 kilometers per second. If deployed, critics charge, the uncertainty surrounding the capability of these defenses could cloud prospects for further reductions in the sizes of nuclear arsenals.

According to some opponents, the Administration's proposed changes would also allow Russia to deploy very capable theater missile defenses with substantial ABM capability--perhaps even those designed as ABMs but just not tested in that mode--without restrictions on geographic location, mobility, or sensors. Indeed, Russia's theater missile defenses could be more capable in an ABM role than U.S. systems if it deployed nuclear-tipped interceptors, something in which it has expressed an interest. Thus, the Administration's proposal would not be a wise policy, critics charge, if the United States, as Secretary of Defense Perry recently stated, needs to maintain a hedge against "the possibility of a hostile, militaristic Russia."[1] It is not clear how U.S. military and nuclear planners would react if they found themselves faced with

1. Secretary of Defense William J. Perry, address delivered at George Washington University, Washington, D.C., March 14, 1994.

a hostile Russia that had very capable theater missile defenses (or untested strategic defenses) deployed at key sites such as missile fields, command and control centers, and urban areas--all of which would be legal under the Administration's November proposal. They would probably be reluctant to reduce U.S. nuclear forces any further and might even want to expand them or deploy advanced "theater" defenses of their own to ensure that the United States could credibly threaten significant destruction with a retaliatory strike.

Some critics have expressed concerns about the effects that deploying advanced theater missile defenses in the United States and Russia or selling them abroad would have on nuclear planning by the small nuclear powers--France, Great Britain, and China--who might feel compelled to increase the size of their nuclear arsenals to be assured of overwhelming the advanced theater ballistic missile defenses deployed by the superpowers.

Supporters of the Administration's proposal argue that the 5-kilometer-per-second threshold is appropriate given what they see as the likely proliferation of longer-range ballistic missiles over the next decade. Although few long-range theater ballistic missiles have been deployed to date, the existence of several programs to develop them--particularly North Korea's efforts to develop the Taepo Dong--portends ill for the future. In their view, the Theater High Altitude Area Defense and probably the Navy's upper-tier defense and the Air Force's boost-phase interceptor are necessary to defend U.S. forces and allied populations against those ballistic missiles and the unconventional weapons they may carry.

Although supporters acknowledge that a system like THAAD will have some capability against strategic missiles, they discount its significance. They argue that, unlike missiles in the developing world, both Russian and U.S. strategic missiles have so-called penetration aids and countermeasures that will easily defeat such systems. More important, according to some supporters, the Administration's proposed changes are essential to keep the ABM viable in a world with longer-range theater ballistic missiles. Only by negotiating a formal demarcation between theater and strategic missile defenses will the firebreak between them be preserved.

Some supporters also argue that the nature of the nuclear balance between the United States and Russia is changing; both sides appear to be backing away from reliance on nuclear weapons as part of their warfighting strategy. In addition, whatever alterations to the treaty are finally agreed on, both sides should be comfortable with them. Thus, a modified treaty need not stand in the way of further cuts in nuclear forces--at least not to the level of 1,000 to 2,000 warheads.

Deploying capable theater missile defenses may, however, hinder the reductions to a few hundred warheads that some have proposed. Moreover, some of the smaller nuclear powers may have interests in theater missile defenses themselves. For example, France and, to some degree, the United Kingdom could be within range of missiles from the Middle East and North Africa if longer-range missiles spread to those regions. Furthermore, there has been no indication in published reports that those countries have objected to the U.S. proposal. Indeed, they are participating, albeit at low levels, in U.S. development programs for theater missile defenses.

In addition, supporters assert that demonstrated capability is the only quantity that can be verified under the provisions of the ABM treaty, which allows verification only by so-called national technical means and makes no provision for on-site inspections. Furthermore, an emphasis on demonstrated capability will avoid many of the squabbles over inherent capability that characterized the ABM debate in the 1980s.

Can Theater Defenses Be Effective Against Strategic Missiles?

As mentioned above, one of the key critiques of the Administration's initial proposal is that its exclusive reliance on target speed to separate theater missile defenses from ABMs would allow Russia and the United States to deploy theater missile defenses that have significant capability against strategic ballistic missiles. Supporters of the Administration acknowledge that theater missile defense systems have some inherent ABM capability, but they do not believe that it is militarily significant.

A group from the Massachusetts Institute of Technology (MIT) and the Union of Concerned Scientists (UCS), an arms control advocacy group, has released a study that examines how effective the Administration's proposed restriction on the target speed would be in creating a firebreak between tactical and strategic missile defense, all else being equal.[2] Using a model of the THAAD system that is, in its view, a conservative approximation of its capabilities, the group shows that THAAD can defend a significant fraction of the area--roughly 70 percent depending on the assumptions used--against a strategic missile with a range of 10,000 kilometers that it can defend against a theater missile with a range of 3,000 kilometers. Using those results, the MIT/UCS group argues that the limit on target speeds proposed by the

2. See Lisbeth Gronlund and others, "Highly Capable Theater Missile Defenses and the ABM Treaty," *Arms Control Today*, vol. 24, no. 3 (April 1994).

Administration cannot, by itself, provide a firebreak between theater and strategic missile defenses. Other limits must be included.

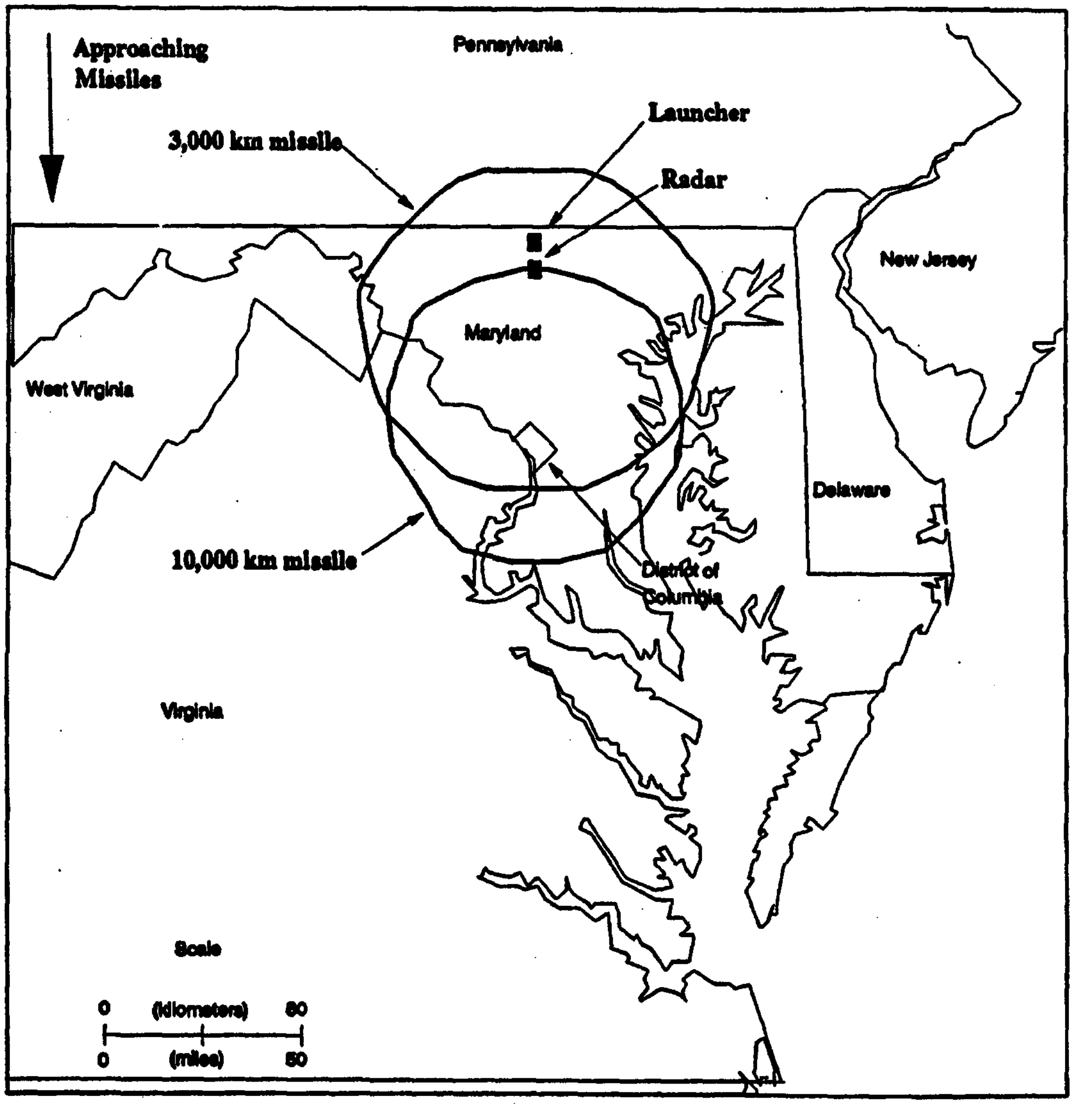
Using a model supplied by the Ballistic Missile Defense Organization, the Congressional Budget Office has achieved a similar result. Using the MIT/UCS group's assumptions of the interceptor's capabilities, the model shows that an area defense roughly similar to THAAD could defend an oval-shaped area approximately 140 kilometers wide and 130 kilometers long against a missile with a maximum range of almost 3,000 kilometers (see Figure 5).[3] That same defense could protect an area 75 percent as large against a strategic ballistic missile with a range of 10,000 kilometers. These results agree well with those reported by the MIT/UCS group.

One should use footprint calculations like those in Figure 5 with caution, however. Like all footprints discussed in this paper, they are for illustrative purposes only. They represent the so-called kinematic--or theoretical--capabilities of the system and do not reflect the probabilities that an incoming warhead will be destroyed. In other words, they only show that the interceptor has the ability to fly out to the point in space required to intercept the target and do not imply that the interception would be successful. Because these kinematic footprints exclude many factors, they most likely overstate somewhat the area that the system can defend. Nevertheless, they are still useful for showing the relative capabilities of various systems.

The actual probability that a system will destroy a given target depends on the characteristics of the interceptor itself and may vary with the speed of the incoming missile. If the interceptor carries a nuclear warhead, such as those designed for the U.S. Safeguard ABM system in the 1970s and the Galosh ABM interceptors still deployed around Moscow, it does not need to get very close to the warhead to destroy it. However, the hit-to-kill interceptors that the United States is developing must actually hit the warhead (and with sufficient speed) to destroy it, much like hitting a bullet with a bullet. Thus, the kill vehicles on the interceptors must be agile enough to correct their course if the target moves or wobbles as it reenters the earth's atmosphere. The degree of agility required depends, of course, on how fast

3. The MIT/UCS group assumed that the interceptor had a maximum speed of 2.6 kilometers per second, burned out in 17 seconds, and could conduct intercepts at altitudes of 40 kilometers or higher. They also assumed that the radar had a range of 300 kilometers and 360 kilometers against missiles with ranges of 3,000 kilometers and 10,000 kilometers, respectively, and that the radar cross section of the incoming warhead was 0.05 square meters in both cases. Finally, they assumed that the radar must track the missile for five seconds before launching an interceptor and that the radar must be able to see the intercept. CBO used an interceptor with a specific impulse of 270 seconds and a mass ratio of 3.25.

FIGURE 5. AREAS DEFENDED BY A THAAD-LIKE DEFENSE AGAINST MISSILES WITH 3,000 KILOMETER AND 10,000 KILOMETER RANGES



SOURCE: Congressional Budget Office based on a model provided by the Ballistic Missile Defense Organization. The results reflect CBO's assumptions about the capability of the defense.

NOTES: The footprints represent the so-called kinematic--or theoretical--capabilities of the system and do not reflect the probability that an incoming warhead will be destroyed. The probability that an interception will be successful is certainly less than one and should vary throughout the footprint. It depends on the capabilities of the interceptor's kill vehicle and also on the scenario--the angle at which the interception occurs, the type of countermeasures, and the number of incoming warheads. Nevertheless, such footprints illustrate the effects of missile range on the area that a system can defend.

THAAD = Theater High Altitude Area Defense.

the target is moving. Consequently, an interceptor designed to destroy targets moving at 3 kilometers per second will probably be less able to destroy targets moving at speeds of 7 kilometers per second.

Supporters of the Administration's policy have several criticisms of the MIT/UCS group's analysis. First, their analysis assumes that the reentry vehicle (the body that surrounds the warhead to protect it from heat during reentry into the earth's atmosphere) of both missiles has the same radar cross section. In other words, the reentry vehicle is equally visible to the radar in both cases. If the cross section of the reentry vehicle on the strategic missile is smaller (which is possible today given the relatively crude warheads found on theater ballistic missiles in the developing world), the area that THAAD could protect could be significantly smaller because the range at which the radar can detect the reentry vehicle is reduced. That is one reason why supporters are not concerned about the effectiveness of THAAD-like systems against strategic missiles. The MIT/UCS group counters that developing future theater ballistic missile warheads with small radar cross sections would be a logical and relatively easy countermeasure for a potential adversary who is capable of building a 3,500 kilometer missile, and any improvements made to THAAD to counter this trend would increase its ability against strategic warheads as well.

Second, supporters argue that THAAD is designed to intercept theater ballistic missiles, which travel slower than strategic missiles. Consequently, the kill vehicle on the THAAD interceptor will not have the maneuverability required to destroy 7-kilometer-per-second strategic missiles.

Third, supporters of the Administration's proposal contend, both U.S. and Russian strategic missiles have the ability to deploy so-called penetration aids (decoys and chaff) and other countermeasures that would overwhelm THAAD or the Navy upper-tier defense. Supporters also point out that THAAD would have trouble providing defense against a sophisticated Russian attack because Russia could use a large number of warheads to overwhelm THAAD and could even explode nuclear weapons at high altitude to blind its radar, which is another reason why supporters do not believe that THAAD has any significant ability against strategic missiles. By contrast, theater missiles currently deployed in the developing world do not carry such countermeasures.

The MIT/UCS group contends that decoys and chaff are easy to develop. Thus, they would be logical for an adversary to deploy on its theater ballistic missiles to counter U.S. defenses. Furthermore, any improvements

made to THAAD to counter penetration aids would increase its ability against strategic missiles as well.

Moreover, the MIT/UCS group contends that, if maintaining the firebreak between theater and strategic missile defense capabilities depends on the difference between theater and strategic radar cross sections and penetration aids, any changes to the ABM treaty must incorporate restrictions on theater missile defenses in these other areas in addition to the limit on target speed that the Administration proposed in November 1993. Otherwise, the firebreak that is central to the treaty cannot be preserved.

Proposed Solutions to the Demarcation Debate

Given that debate continues over the Administration's proposal both with Russia and within the United States, other modifications to the ABM treaty may emerge that are acceptable to both sides and would allow the United States and Russia to deploy adequate theater missile defenses while preserving the integrity of the treaty. Reportedly, Russia has already proposed some modifications in response to the Administration's proposal; critics of the Administration's proposal have suggested others. For example, the United States and Russia could agree to:

- Reduce the proposed threshold for maximum target speed to something less than 5 kilometers per second;
- Limit the maximum speed of a theater missile defense interceptor;
- Limit the altitude of intercepts;
- Limit the number of theater missile defense launchers or interceptors;
- Limit the areas where theater missile defense could be deployed or the concentration of theater missile defense systems within U.S. and Russian territory;
- Ban tests of theater missile defenses against targets with penetration aids;
- Limit the power of theater missile defense radars;

- o Limit the number of ground-, air-, or sea-based platforms; and
- o Allow inspections to verify exchanged data.

Each of the modifications would limit to some degree the capabilities of the theater missile defense systems that otherwise would be allowed under the Administration's proposal. As such, they may not be acceptable to the Administration or its supporters. Yet agreement with Russia and winning sufficient support within the Senate may not be possible without some modification to the Administration's proposal. A compromise approach might include more than one of these changes.

BRILLIANT EYES AND THE ANTI-BALLISTIC MISSILE TREATY

Another system that raises issues with the ABM treaty is the proposed constellation of space-based sensors known as Brilliant Eyes. The issue is whether Brilliant Eyes could substitute for an ABM radar, one element of an ABM system that the treaty strictly limits to hedge against breakout.

As discussed in Chapter III, Brilliant Eyes will have the ability to track ballistic missiles from the time they pass above the clouds until they reenter the atmosphere. According to the Air Force, the data from Brilliant Eyes will be good enough that future ground-based area defenses can, in theory, intercept warheads completely outside of the view of the ground-based radar. Yet, according to the Ballistic Missile Defense Organization, neither the currently planned theater missile defenses nor the current design for Brilliant Eyes will include the communications links that would be required to take advantage of this capability.

If Brilliant Eyes was only usable for theater missile defense, it would not conflict with the ABM treaty because the treaty does not limit such defenses. However, the sensors raise compliance issues on two counts. First, when deployed with its planned complement of sensors, Brilliant Eyes will be able to track strategic as well as theater ballistic missiles and, in the case of strategic missiles, might be considered a substitute for an ABM radar, which the treaty limits.

This issue has been the subject of vigorous debate for several years in the United States and has yet to be resolved. Supporters of Brilliant Eyes point out that the treaty allows space-based early-warning sensors such as Defense Support Program satellites and ground-based early-warning radar, and that by extension Brilliant Eyes should be permitted as well. Opponents

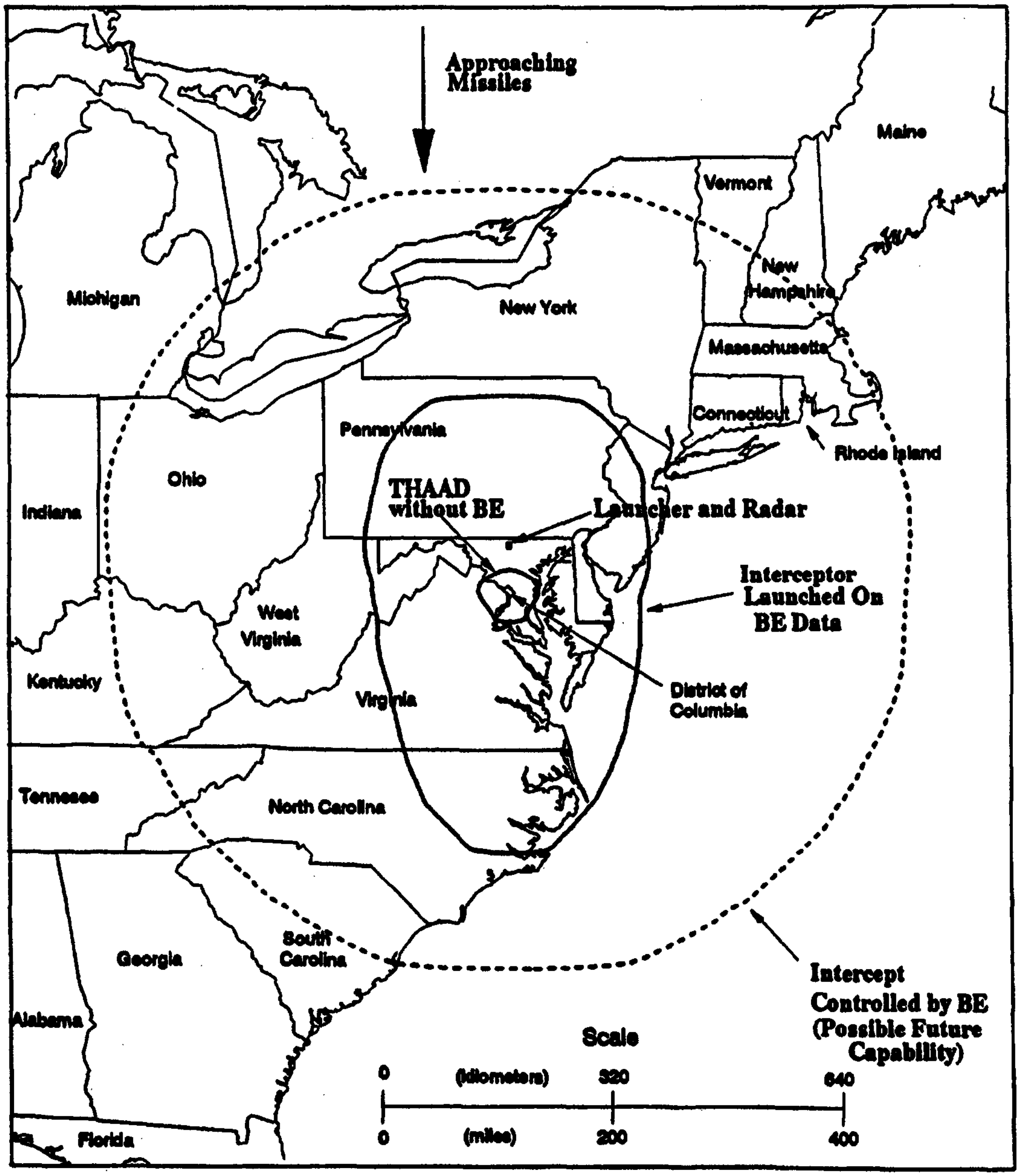
retort that the midcourse tracking that Brilliant Eyes provides is fundamentally different from what an early-warning sensor can do. That point is demonstrated by statements of the Ballistic Missile Defense Organization that Brilliant Eyes could guide an interceptor to its target without the target ever being seen by the ground-based ABM radar. In theory, the entire interception could occur without ever turning the ABM radar on. In fact, Brilliant Eyes will be most effective for tracking strategic warheads because they spend far more time outside the atmosphere than do theater ballistic missiles. Indeed, the Ballistic Missile Defense Organization is developing the satellites for both national and theater ballistic missile defenses. Making the distinction between theater and strategic roles is difficult for Brilliant Eyes because the satellites are in orbit all the time and are thus available for either type of defense.

Supporters of Brilliant Eyes point out that although it is technically feasible to intercept missiles beyond the range of the ground-based radar, none of the currently planned systems will have that capability. Both the interceptors and the satellites lack the communications links necessary for them to talk with each other (see Chapter III).

The second compliance issue that Brilliant Eyes raises is its ability to greatly expand the area defended by a theater defense. To put it another way, even if Brilliant Eyes were not considered a substitute for an ABM radar, it could increase the capability of a theater missile defense that complied with the Administration's 5-kilometer-per-second threshold to the point that it could have a significant capability against strategic missiles, effectively creating an ABM system. For example, if the THAAD-like system illustrated in Figure 5 were augmented by tracking data from Brilliant Eyes, it could launch its interceptors before its radar could see the incoming missile. Consequently, the area it could theoretically defend against a strategic missile with a speed of 7 kilometers per second would be 25 times larger (see Figure 6). If, in the future, data from Brilliant Eyes could be sent directly to the interceptor, that same area defense could not only launch its interceptors before the radar detected the missile but actually intercept the missile beyond the range of its radar. Therefore, the system could defend a significantly larger area. The model indicates that the area it could theoretically defend in that case would be 135 times larger than the same scenario without Brilliant Eyes.

As mentioned above, footprint calculations such as those in Figure 6 must be used with caution. In short, the kinematic footprints used in this paper do not reflect the probability that an intercept will occur. Such

FIGURE 6. AREAS DEFENDED BY A THAAD-LIKE DEFENSE AIDED BY BRILLIANT EYES AGAINST A MISSILE TRAVELING AT 7 KILOMETERS PER SECOND



SOURCE: Congressional Budget Office based on a model provided by the Ballistic Missile Defense Organization. The results reflect CBO's assumptions about the capability of the defense.

NOTES: The footprints represent the so-called kinematic--or theoretical--capabilities of the system and do not reflect the probability that an incoming warhead will be destroyed. The probability that an interception will be successful is certainly less than one and should vary throughout the footprint. It depends on the capabilities of the interceptor's kill vehicle and also on the scenario--the angle at which the interception occurs, the type of countermeasures, and the number of incoming warheads. Nevertheless, such footprints illustrate the effect that space-based sensors like Brilliant Eyes have on the area that a system can defend.

THAAD = Theater High Altitude Area Defense; BE = Brilliant Eyes.

probabilities are certainly less than one and vary throughout the footprint. They depend on the capabilities of the interceptor's kill vehicle and also on the scenario--the type of countermeasures and the number of incoming warheads. Thus, the footprints shown in Figure 6 do not prove that THAAD would be effective over such areas, particularly against a high-speed strategic target. What the footprints do show, however, is that Brilliant Eyes would significantly improve the capability of an area defense like THAAD by allowing it to launch its interceptors earlier. It should also provide some ability to distinguish warheads from decoys.

The Administration's Plan for the ABM Compliance of Brilliant Eyes

The Administration has not directly addressed the issue of ABM compliance for Brilliant Eyes. Published reports do not indicate whether or not it has attempted to reach an agreement with Russia that would clarify the issue. However, mindful of concerns about compliance, it has designed its initial flight test of two satellites so that they will not have the capacity to transmit the data from their sensors in real time, an ability that would be essential for Brilliant Eyes to have any ABM capability. Whether this will be considered compliant by the Congress or Russia remains to be seen.

Other Possible Approaches to Brilliant Eyes Compliance

If Brilliant Eyes in its planned configuration is not permitted by the ABM treaty, the system might be changed in several ways so that it can be used against theater ballistic missiles.

One possible approach is to deploy Brilliant Eyes in so-called low-inclination orbits that stay within 20 or 30 degrees of the equator. It is in these latitudes that theater ballistic missiles are most common. The satellites would not be deployed over the northerly latitudes where Russian intercontinental ballistic missiles and much of the United States are located. This option may address ABM concerns to some degree.

Another approach is to deploy Brilliant Eyes without its long-wave infrared sensor, which is most useful for detecting the very cool objects associated with intercontinental ballistic missiles. The remaining medium-wave infrared sensor might be sufficient against theater ballistic missiles because they are in space for such a short time that the warheads do not cool much. (This assumes that the warheads are not insulated to make them appear cold.) However, because a medium-wave sensor cannot detect very

cold objects, it would have only a modest capability against intercontinental missiles and primarily during the first portion of their flight.

Removing the long-wave sensor may be enough to limit the ability of Brilliant Eyes to aid in a national missile defense. But eliminating a sensor would be difficult to verify by national technical means--the only means of verification currently allowed by the ABM treaty. For example, how would Russia know how sensitive the remaining sensors were? To strengthen the means for verification, the parties to the treaty could agree to changes in the treaty that would allow sharing telemetry or on-site inspections, both of which have precedents in the START treaties.

CHAPTER V

ALTERNATIVES TO THE ADMINISTRATION'S PLAN FOR ACTIVE TMD

Several criticisms have been leveled at the Administration's plan for theater missile defense. Some opponents believe that it is too costly. Others worry about the issues that some systems would raise with the Anti-Ballistic Missile Treaty. Still others contend that the Administration does not plan to spend enough on those programs.

To illustrate the effects of different approaches to theater missile defenses that would address some of those concerns, the Congressional Budget Office has analyzed four alternatives to the Administration's plan. The first option would deploy point defenses only and not area defenses like the Theater High Altitude Area Defense. Option II would fund the Administration's so-called core systems--Patriot Advanced Capability, Level 3, Theater High Altitude Area Defense, and the Navy lower-tier defense--but it would not develop other systems like the Corps Surface-to-Air Missile, boost-phase interceptors, or the Navy upper-tier defense. Nor would it deploy Brilliant Eyes. Option III is exactly like Option II except that it would also deploy Brilliant Eyes. The final option CBO analyzed would develop noncore systems more quickly than the Administration's plan.

None of these options would affect funding for non-TMD efforts within the Ballistic Missile Defense Organization, with the exception of Brilliant Eyes. Also, none of the options would affect funding for other means of reducing the threat of theater ballistic missiles--attack operations, passive defenses, efforts to control proliferation, or measures to reduce the likelihood of conflict. However, savings from the options could be used to augment funding for the other pillars of theater missile defense discussed in Chapter III. In addition, CBO's estimates of savings exclude those achieved by not having to operate the systems that have been canceled.

OPTION I: DEPLOY POINT DEFENSES ONLY

Option I is a low-cost approach to theater missile defense that would comply with the ABM treaty as currently interpreted. For those reasons, this option would not develop area defenses like the Theater High Altitude Area Defense or the Navy upper tier, or boost-phase defenses like the boost-phase interceptor or the airborne laser. Instead, this option would rely on upgrades to existing systems rather than develop entirely new ones. Consequently, it

would deploy the PAC-3 system and the Navy lower-tier defense, which is an upgrade to the Aegis/Standard missile air-defense system (see Table 10). This option would also deploy the first version of the Alert, Locate, and Report Missiles early-warning sensor, although it would not fund the upgrades for the second and third blocks of satellites. Nor would it develop the Brilliant Eyes space-based sensors.

The Effect on Costs

This option would save substantial sums. In 1995, for example, Option I would save $1.0 billion from the Administration's request of $2.7 billion (see Table 11). From 1995 through 1999, this option would save $5.6 billion. Most of those savings through 1999 would come from canceling THAAD ($3.4 billion); the remaining savings would come in roughly equal parts from canceling the advanced-capability TMD systems, Brilliant Eyes, and a 20 percent reduction in the operational support funding for TMD efforts within the BMDO budget to reflect the smaller scope of the TMD project. Annual expenditures for the latter category total roughly $400 million, so savings would be about $80 million per year.

Through 2010, this option would save more than $27 billion, of which the largest component would be the advanced-capability TMD systems ($12.8 billion). Most of the remaining savings would come from canceling THAAD ($8.1 billion), Brilliant Eyes ($3.3 billion), and upgrades to ALARM ($2 billion). Reductions in TMD operational support would contribute $1.1 billion in savings over this period.

The Effect on Capability

The cuts outlined in this option would have significant effects on capability compared with the Administration's plan. Although it would develop two of the three core systems, it would forgo area defenses altogether. As discussed in Chapters II and III, area defenses provide an upper layer of defense that improves the effectiveness of the point defenses and can defend wider areas against missiles with longer ranges. Without an upper layer, PAC-3 and the Navy lower-tier defense will have more difficulty defending their relatively small areas, and many more of them would have to be deployed to defend area targets like cities.

TABLE 10. ALTERNATIVES TO THE ADMINISTRATION'S PLAN FOR THEATER MISSILE DEFENSE

	Core TMD Systems			Advanced-Capability TMD[a]			TMD-Related Space-Based Sensors		Other TMD	
Options	PAC-3	Navy Lower-Tier	THAAD	Corps SAM	Navy Upper-Tier	BPI[b]	Brilliant Eyes	ALARM Upgrades[c]	Airborne Laser	Reduce Support[d] (Percent)
Administration's Plan	X	X	X	X	X	X	X	X	X	0
I. Deploy Point Defenses Only	X	X								20
II. Deploy Core Systems	X	X	X							10
III. Deploy Core Systems and Brilliant Eyes	X	X	X				X			10
IV. Increase TMD Funding	X	X	X	X[e]	X[e]	X[e]	X	X	X	0

SOURCE: Congressional Budget Office.

NOTES: All options leave unchanged the Administration's plan for attack operations and national missile defenses (with the exception of Brilliant Eyes). TMD = Theater Missile Defense; PAC = Patriot Advanced Capability; THAAD = Theater High Altitude Area Defense; SAM = Surface-to-Air Missile; BPI = Boost-Phase Interceptor; ALARM = Alert, Locate, and Report Missiles.

a. The Ballistic Missile Defense Organization (BMDO) plans to select one of these systems in 1998 for full development and production based on guidance from the Joint Chiefs of Staff. The other two would be developed beyond 1999 if budget constraints permit.

b. According to the Air Force, the Boost-Phase Interceptor would also require a new airborne multipurpose sensor and cueing platform.

c. All options develop the first generation of ALARM early-warning satellites. However, some options do not fund the upgrades planned by the Air Force.

d. Operational support funding in the BMDO budget for TMD activities would be reduced about 20 percent for Option I to reflect the smaller scope of activities. Options II and III would decrease this funding by 10 percent.

e. This option adds $200 million per year to the Administration's budget for the three advanced-capability TMD systems (Corps SAM, Navy Upper-Tier, and Boost-Phase Interceptor). It would accelerate deployment of at least one of those systems but does not specify which ones would be affected.

TABLE 11. COSTS OF THE ADMINISTRATION'S THEATER MISSILE DEFENSE PLAN AND SAVINGS FROM VARIOUS CBO OPTIONS

						Total		
Category	1995	1996	1997	1998	1999	1995 to 1999	1999 to 2010	1995 to 2010
			CBO's Estimate of the Administration's Plan					
Core Systems	1.5	1.6	1.4	1.5	1.7	7.7	9.0	16.7
Advanced-Capability TMD	0.1	0.1	0.1	0.3	0.4	1.0	11.7	12.8
Brilliant Eyes	0.1	0.1	0.1	0.2	0.2	0.8	2.5	3.3
ALARM	0.2	0.2	0.1	0.3	0.5	1.2	6.9	8.1
Other TMD	0.5	0.4	0.4	0.4	0.4	2.2	3.8	6.0
Total	2.7	2.8	2.6	2.9	3.4	14.3	35.7	50.0
			Savings from Option I: Deploy Point Defenses Only					
Core Systems	0.7	0.6	0.5	0.6	1.0	3.4	4.7	8.1
Advanced-Capability TMD	0.1	0.1	0.1	0.3	0.4	1.0	11.7	12.8
Brilliant Eyes	0.1	0.1	0.1	0.2	0.2	0.8	2.5	3.3
ALARM	0	0	0	0	0	0	2.0	2.0
Other TMD	0.1	0.1	0.1	0.1	0.1	0.4	0.7	1.1
Total	1.0	1.0	0.9	1.2	1.7	5.6	21.6	27.2
			Savings from Option II: Deploy Core TMD Systems					
Core Systems	0	0	0	0	0	0	0	0
Advanced-Capability TMD	0.1	0.1	0.1	0.3	0.4	1.0	11.7	12.8
Brilliant Eyes	0.1	0.1	0.1	0.2	0.2	0.8	2.5	3.3
ALARM	0	0	0	0	0	0	2.0	2.0
Other TMD	a	a	a	a	a	0.2	0.3	0.5
Total	0.3	0.4	0.3	0.6	0.6	2.0	16.6	18.6
			Savings from Option III: Deploy Core TMD Systems and Brilliant Eyes					
Core Systems	0	0	0	0	0	0	0	0
Advanced-Capability TMD	0.1	0.1	0.1	0.3	0.4	1.0	11.7	12.8
Brilliant Eyes	0	0	0	0	0	0	0	0
ALARM	0	0	0	0	0	0	2.0	2.0
Other TMD	a	a	a	a	a	0.2	0.3	0.5
Total	0.1	0.2	0.2	0.4	0.5	1.2	14.1	15.3
			Savings from Option IV: Increase Funding for Advanced-Capability TMD					
Core Systems	0	0	0	0	0	0	0	0
Advanced-Capability TMD	-0.2	-0.2	-0.2	-0.2	-0.2	-1.0	-2.2	-3.2
Brilliant Eyes	0	0	0	0	0	0	0	0
Other TMD	0	0	0	0	0	0	0	0
Total	-0.2	-0.2	-0.2	-0.2	-0.2	-1.0	-2.2	-3.2

SOURCE: Congressional Budget Office.

NOTES: Estimates of savings exclude those achieved by not having to operate systems that have been canceled.
CBO = Congressional Budget Office; TMD = Theater Missile Defense; ALARM = Alert, Locate, and Report Missiles.

a. Less than $50 million.

From a military point of view, point defenses may be effective enough to protect assets toward the rear of the theater from most ballistic missiles available today. Those defenses may be less effective, however, against longer-range missiles. And point defenses by themselves may not provide adequate protection against missiles armed with nuclear, chemical, or biological warheads. These weapons may disperse their agents too high in the atmosphere for an interceptor from a point defense to reach them. Furthermore, the damage that such weapons can inflict may make even low levels of leakage through a single-layer defense unsatisfactory. Warheads composed of conventional submunitions that can be dispersed at high altitudes would also challenge these systems.

The area defenses not deployed in this option could also provide some protection for troops deployed near the front, the majority of whom are likely to be in areas not protected by point defenses. Nevertheless, troops in the forward areas are much more likely to face attacks by short-range missiles like Frogs (with ranges of 70 kilometers), which would underfly an upper-tier defense like THAAD. Furthermore, longer-range theater ballistic missiles would have only marginal utility against maneuver forces; they move too quickly and would be difficult for an adversary without substantial airborne surveillance assets to locate.

By developing only the first generation of ALARM satellites, this option would provide U.S. commanders with the ability to detect and track shorter-range theater ballistic missiles like Scud-Bs in two regions of the world, but not the ability to detect such missiles worldwide. Nor would it allow data from the satellite to be transmitted directly to theater commanders and other sensor platforms in the theater. However, U.S. forces may not be deployed in more than two regional conflicts simultaneously, so continuous global coverage may not be needed. Furthermore, data from the initial ALARM satellites will still be transmitted to the theater as fast, if not faster, than data from the Defense Support Program satellites were during the Persian Gulf War. The initial ALARM satellites will provide less warning of an impending attack than upgraded versions, but given the events in that war, a few minutes may be sufficient, particularly if longer-range missiles are used.

Finally, canceling the sensor program would reduce some of the overlap in space-based sensors that the Congress has identified in recent years. To encourage DoD to consolidate programs, it put money for DSP, the Follow-on Early-Warning System, and Brilliant Eyes into a single account in the Defense Authorization Act for 1994.

In sum, this option would provide a modern land- and sea-based point defense capability toward the rear areas of the theater that could offer some protection for critical targets against missiles with ranges of 1,000 kilometers or less. If area defenses are required to protect allied populations, this option would require allied nations to develop such defenses themselves. Furthermore, if an adversary had only a very small arsenal of nuclear weapons (the most likely scenario for developing nations), it would probably not squander those few weapons on combat forces. More likely, it would threaten to use them against the population centers of its opponent or use them as a last resort. The same may be true for biological weapons. Chemical weapons can be countered by proper passive defense measures, although such measures would probably slow down military operations.

The Effect on Treaty Compliance

This option would also avoid raising compliance issues with the ABM treaty. As mentioned in Chapter IV, several elements of the Administration's plan raise issues with the treaty, including area defenses, boost-phase defenses, and space-based sensors. The Administration is trying to negotiate an agreement with Russia that would clarify the dividing line between theater and strategic ballistic missile defenses in such a way that THAAD, the Navy upper-tier defense, and boost-phase interceptors would be allowed by the ABM treaty. One could also reasonably expect that the Administration will try to reach an agreement with Russia that will allow the United States to deploy Brilliant Eyes. Because this option would forgo those systems, it would probably avoid the need to clarify or modify the ABM treaty, at least during this decade.

OPTION II: DEPLOY THE CORE THEATER MISSILE DEFENSE SYSTEMS

Option II represents a more moderate and less costly alternative to the Administration's plan; the approach may also minimize compliance problems with the ABM treaty. Yet Option II would deploy most of the systems sought by the Administration. It would deploy a robust multitiered defense featuring the three core theater missile defense systems that the Ballistic Missile Defense Organization plans to develop over the next five years: PAC-3, THAAD, and the Navy lower-tier defense. In addition, it would fund the development of the command and control system that would allow those elements to function effectively together.

Option II would not fund any of the advanced theater missile defense systems that the Administration is developing (see Table 10 on page 65). Nor would it fund the Brilliant Eyes space-based sensor or the airborne laser.[1] Like Option I, however, it would develop the Air Force's first-generation ALARM early-warning satellite program but not the advanced version planned for the next decade.

The Effect on Costs

Option II will save about $300 million in 1995 and $2 billion through 1999, relative to the Administration's plan for all theater missile defense activities (see Table 11 on page 66). Through 2010, this option would save nearly $19 billion, much of it from canceling the three advanced-capability TMD systems ($12.8 billion), Brilliant Eyes ($3.3 billion), and the upgrades to ALARM ($2 billion). Smaller savings of about $40 million per year in other theater missile defense efforts would accrue for the same reasons as in Option I. However, those savings are slightly smaller in this option because CBO assumes that the operational support funding would be trimmed by 10 percent, rather than the 20 percent assumed in Option I.

The Effect on Capability

Those savings would not come without reducing the capability of the defenses relative to the Administration's plan. Forgoing boost-phase interceptors would not only reduce the number of layers that could intercept a missile, but it would reduce the ability of U.S. forces to intercept missiles tipped with unconventional warheads or submunitions over an adversary's territory. Eschewing the sea-based upper-tier defense would eliminate the ability to provide area defense in the future without having to rely on airfields for deployment. It would also reduce the ability of U.S. forces to defend wide areas of Japan and Europe in the future if they were attacked by missiles from North Korea or Iraq, respectively. Canceling Corps SAM would significantly reduce the future ability of U.S. maneuver forces deployed near the front to protect themselves against short- and medium-range ballistic missiles. Finally, canceling the Brilliant Eyes program would foreclose the option of providing midcourse tracking and cueing data to expand the areas that a THAAD battery or Navy upper-tier system could defend. It would also eliminate a critical component of any future national missile defense.

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1. The Bottom-Up Review report, issued in October 1993, included Brilliant Eyes in its core TMD program. In testimony this spring, the Ballistic Missile Defense Organization has backed away from this position, preferring to exclude the space-based sensors from its core programs. CBO uses this most recent definition.

Nevertheless, Option II would provide the same capability to protect both point and area targets that the Administration plans to deploy over the next decade, including THAAD. It just would not continue to develop more advanced defenses or sensors. There may be good reasons for canceling those systems. The tight budget environment may make the extra protection and duplication that they offer unaffordable. For example, in the face of U.S. air supremacy, regional adversaries may never develop the ability to locate U.S. maneuver forces and attack them effectively with ballistic missiles. Thus, Corps SAM may not be needed for ballistic missile defense, although the need to protect against cruise missiles may remain. Boost-phase interceptors and the airborne sensor platforms that they are likely to require may be too expensive given that they will have to rely on terminal defenses to intercept the missiles that were launched out of their range. A sea-based upper-tier defense would duplicate THAAD for defending U.S. land-based forces in many cases. In addition, its greatest strength, defending allies such as Japan and Europe from attacks by theater ballistic missiles over water, is perhaps most appropriately paid for by those other countries.

The Effect on Treaty Compliance

Because Option II would not develop the Navy upper-tier system or boost-phase interceptors, it should mitigate to some degree the concerns of ABM supporters who worry that the Administration's proposed clarification would undermine the ABM treaty. As mentioned in Chapter IV, the Administration has proposed a clarification to the ABM treaty that would allow any missile defense system tested only against targets with maximum speeds of 5 kilometers per second or less to be considered a theater missile defense system free from treaty restrictions. Russia, apparently concerned about theater missile defense systems with significant capability against strategic ballistic missiles, has reportedly offered to accept the Administration's proposal only if a limit of 3 kilometers per second is placed on the maximum speed of theater missile defense interceptors. That limit would permit the United States to develop THAAD, which reportedly has a maximum interceptor speed of 2.5 to 2.8 kilometers per second, but would forbid it to develop the Air Force boost-phase interceptor and the Navy upper-tier system that will reportedly have maximum speeds of 3 to 4 kilometers per second and 4.3 to 4.8 kilometers per second, respectively. Consequently, Option II would deploy only those interceptor systems that seem less contentious in current negotiations and in the Senate.

Brilliant Eyes could also raise issues with the ABM treaty (see Chapter IV). By not developing this system further, Option II avoids these issues as well.

OPTION III: DEPLOY THE CORE THEATER MISSILE DEFENSE SYSTEMS AND BRILLIANT EYES

This option is much like Option II except that it would take a different approach to space-based sensors. In addition to deploying ALARM, this option would also deploy Brilliant Eyes (see Table 10 on page 65). Although this approach would be more expensive than deploying the core systems without Brilliant Eyes, it may provide a better mix of sensors for theater missile defense.

The savings from Option III relative to the Administration's plan would be smaller than the previous option because of the cost to develop Brilliant Eyes. Yet this option would save about $100 million in 1995 by halting the development of the advanced-capability TMD systems and the airborne laser. Through 1999 it would save about $1.2 billion, and through 2010 it would reduce the TMD budget by $15.3 billion.

Option III would take advantage of the ability of Brilliant Eyes to track theater ballistic missiles in midcourse. Such data would expand the area that these terminal defenses will be able to defend--especially area defenses like THAAD and the Navy upper-tier system--by cueing their radar to the proper location and allowing the system to launch its interceptors while the target is still outside of the radar's range. Future theater missile defenses may be able to conduct the entire intercept outside radar range based on data from Brilliant Eyes, expanding the defended areas even further.

Nevertheless, Brilliant Eyes will only be useful against theater ballistic missiles with long ranges. Missiles with ranges much less than 600 kilometers do not spend much time in space and are within radar range for most area defenses for much of their trajectory. If long-range theater ballistic missiles are unlikely to proliferate to the developing world, Brilliant Eyes may not be a wise investment. Developing Brilliant Eyes could also raise treaty compliance issues with the ABM treaty. (Another alternative, deploying a Brilliant Eyes constellation that is designed for theater missile defenses, is discussed in Chapter IV.) Finally, by canceling the upgrades to ALARM, Option III would reduce some of the overlap in space-based sensors that the Congress has expressed concern about in recent years.

There are other ways, however, to reduce the overlap between ALARM and Brilliant Eyes. One approach would cancel ALARM and develop instead a new version of DSP without any of the new capabilities against theater ballistic missiles that have been proposed for the ALARM system. It would rely instead on Brilliant Eyes to provide the early warning of theater ballistic missile launches with its downward-looking sensor, in addition to its midcourse tracking capability. Although this approach would limit coverage to two theaters at any one time, such a limitation may be acceptable given the budget constraints and the current international situation.

This approach hinges on the ability of Brilliant Eyes to detect launches of theater ballistic missiles. As long as at least one satellite is looking at the region of the globe where the missile is launched with its short-wave infrared sensor, Brilliant Eyes should be able to detect and track theater ballistic missiles during the boost phase as well as ALARM. According to unclassified charts from the Air Force, a Brilliant Eyes constellation should be able to keep two areas on the earth roughly the size of Iraq or the Korean peninsula under surveillance at all times. DoD's Bottom-Up Review assumed that U.S. forces were not likely to be involved in more than two major regional contingencies at the same time. Thus, as long as this assumption is valid, Brilliant Eyes should be able to provide early warning of theater ballistic missile attacks to all U.S. forces involved in regional conflicts. Early warning of strategic ballistic missile launches and any theater missiles that are launched outside of the two hot spots would be provided by the new DSP satellites, as it is today. Furthermore, after the first missile is launched in a region not under continuous surveillance by Brilliant Eyes, the constellation can quickly shift its survey to that new region.

OPTION IV: INCREASE FUNDING FOR ADVANCED THEATER MISSILE DEFENSE SYSTEMS

Some supporters of theater missile defense have criticized the Administration's plan for not spending enough on active defenses. Option IV would accelerate the development of the three advanced-capability theater missile defense systems: Corps SAM, the sea-based upper-tier defense, and boost-phase intercept (see Table 10 on page 65).

To accelerate development, Option IV would increase the funding for those programs by $200 million per year starting in 1995 and going through 2010 (see Table 11 on page 66). All other funding would remain the same as in the Administration's plan. Because detailed spending plans for the sea-based upper-tier defense and boost-phase interceptors are not available, this

option does not specify how the extra $200 million per year would be spent. It could be used to accelerate the development of one system or speed up work on all three to a lesser extent. Because of this uncertainty, CBO cannot estimate the new schedules for each system.

Option IV offers the obvious benefit of providing more capable defenses earlier than the Administration planned. Having more types of defenses at their disposal sooner will give U.S. commanders more flexibility in facing various regional contingencies. They could opt to deploy land-based systems or keep a lower profile by deploying sea-based systems to protect allied populations and key embarkation points for U.S. forces. Similarly, they could opt to deploy boost-phase defenses if the adversary possesses ballistic missiles armed with unconventional weapons or submunitions. A combination of all these systems may be required to protect U.S. forces adequately if ballistic missiles and weapons of mass destruction proliferate more quickly than the Administration anticipates.

Yet getting these capabilities earlier comes at a price that may not be acceptable in the current austere budget climate. Option IV would increase theater missile defense funding by $200 million a year and $3.2 billion through 2010. Deploying systems earlier would also increase operating and support costs, although by how much depends on which systems would be deployed earlier than what was planned by the Administration. The extra funding required for this option would have to come from other DoD programs unless the total DoD budget were increased. Money could also come from the National Missile Defense program within BMDO's budget. Although the national missile defense budgets are a fraction of what they were several years ago and do not support any system development programs, they may be the only source of money. Nevertheless, an annual reduction of $200 million would represent about a 20 percent reduction in planned national missile defense budgets through 1999 (see Table 6 on page 41).

Furthermore, accelerating the development of these programs could raise compliance issues with the ABM treaty earlier than the Administration's plan unless the Administration successfully convinces Russia (and the Senate) to accept its 5-kilometer-per-second dividing line between theater and strategic ballistic missiles.

APPENDIX

To allow accurate comparisons of the Administration's plan and the options, costs throughout this paper are expressed in billions of 1995 dollars of budget authority. However, this appendix presents two important tables (Tables 6 and 7) in billions of current dollars, which are more commonly used.

TABLE A-1. CBO'S ESTIMATE OF THE ADMINISTRATION'S BUDGET REQUEST FOR THE BALLISTIC MISSILE DEFENSE ORGANIZATION
(By fiscal year, in billions of dollars)

Category	1995	1996	1997	1998	1999	Total 1995 to 1999	Total 1999 to 2010	Total 1995 to 2010
			Theater Missile Defense[a]					
Core Systems	1.5	1.6	1.5	1.7	1.9	8.2	11.3	19.5
Advanced-Capability TMD Systems	0.1	0.1	0.1	0.3	0.4	1.1	16.1	17.3
TMD Research and Support	0.4	0.4	0.4	0.4	0.4	2.1	4.5	6.6
International Systems	0.1	b	b	b	0.1	0.2	0.6	0.8
Subtotal	2.1	2.2	2.1	2.5	2.8	11.6	32.5	44.2
			National Missile Defense and Other Efforts					
National Missile Defense, Research, and Support	1.0	1.0	1.0	1.0	1.0	5.0	11.0	16.0
Brilliant Eyes Satellite	0.1	0.2	0.2	0.2	0.2	0.8	3.3	4.1
Subtotal	1.2	1.2	1.2	1.2	1.2	5.9	14.3	20.1
			Total Ballistic Missile Defense Organization Budget					
Total	3.3	3.4	3.3	3.7	4.0	17.6	46.8	64.4

SOURCE: Congressional Budget Office based on information from the Department of Defense.

NOTE: TMD = theater missile defense.

a. Includes boost-phase interceptor funds of $1.4 billion.

b. Less than $50 million.

TABLE A-2. CBO'S ESTIMATE OF THE ADMINISTRATION'S BUDGET REQUEST FOR THEATER MISSILE DEFENSE AND SPACE-BASED SENSORS
(By fiscal year, in billions of dollars)

Category	1995	1996	1997	1998	1999	Total 1995 to 1999	Total 1999 to 2010	Total 1995 to 2010
BMDO's Theater Missile Defense Activities								
Core Systems								
PAC-3	0.6	0.7	0.5	0.5	0.4	2.7	0.5	3.2
THAAD/GBR	0.7	0.6	0.6	0.7	1.1	3.8	6.9	10.7
Navy lower-tier	0.2	0.3	0.3	0.3	0.3	1.4	3.4	4.7
Battle management	a	a	0.1	0.1	0.1	0.3	0.6	0.9
Subtotal	1.5	1.6	1.5	1.7	1.9	8.2	11.3	19.5
Advanced Capability TMD Systems								
Corps SAM	a	a	a	a	a	0.2	0.5	0.6
Navy upper-tier	a	a	a	a	a	0.2	0.5	0.6
Boost-phase interceptor	0.1	0.1	0.1	0.1	0.1	0.4	1.0	1.4
Dem/Val Program	0	0	0	0.2	0.3	0.4	14.3	14.7[b]
Subtotal	0.1	0.1	0.1	0.3	0.4	1.1	16.1	17.3
TMD Research and Support	0.4	0.4	0.4	0.4	0.4	2.1	4.5	6.6
International	0.1	a	a	a	0.1	0.2	0.6	0.8
Total	2.1	2.2	2.1	2.5	2.8	11.6	32.5	44.2
Other Theater Missile Defense Activities								
Air Force TMD								
Airborne laser	a	a	a	a	a	0.1	0.2	0.3
Attack operations	a	a	a	a	a	0.2	0.4	0.5
Boost-phase interceptor	0.1	0.1	0.1	a	a	0.2	0.2	0.4
Army Patriot Upgrades	0.1	a	a	a	a	0.2	0.1	0.3
ARPA Warbreaker Program	0.1	0.1	0.2	0.1	0.1	0.7	1.5	2.3
Total	0.3	0.3	0.3	0.2	0.3	1.4	2.4	3.8
TMD-Related Space-Based Sensors								
ALARM	0.2	0.2	0.2	0.3	0.6	1.3	9.2	10.6[b]
Brilliant Eyes	0.1	0.2	0.2	0.2	0.2	0.8	3.3	4.1
Total Theater Missile Defense and Space-Based Sensors								
All Programs	2.7	2.9	2.7	3.2	3.8	15.2	47.4	62.6

SOURCE: Congressional Budget Office based on information from the Department of Defense.

NOTES: Costs exclude those to operate a system after it has been deployed. BMDO = Ballistic Missile Defense Organization; PAC = Patriot Advanced Capability; THAAD = Theater High Altitude Area Defense; GBR = Ground-Based Radar; ARPA = Advanced Research Projects Agency; TMD = Theater Missile Defense; ALARM = Alert, Locate, and Report Missiles.

a. Less than $50 million.

b. Total costs for advanced-capability TMD and ALARM are higher than these figures because the programs continue beyond 2010.